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THE ALPINE AND SUBALPINE VEGETATION OF THE LAKE TAHOE REGION

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(WITH FOUR FIGURES)

Geology

The country rock of the region is mainly a coarse granite, which represents the ancient Sierran batholith. The sedimentary rocks which formed the more ancient surface, and under which the intrusives were thrust, have been for the most part completely eroded away; what little remains, as on the summit of Mt. Tallac, has been changed by pressure and heat into schistose rocks, and these have become deeply fissured by jointing. Under the degrading influence of the alpine climate, with rapid changes of temperature and moisture, these jointed slates and schists have been ever more deeply fractured and loosened from place, giving rise to the immense heaps of angular talus, which skirt the bases of Mt. Tallac, Maggie's Peaks, and Castle Peak. The metamorphosed sedimentary rocks increase southward, but REID (1) points out that "The largest areas are little more than a veneer over the granite, so that it is evident that the work of removing the roof of the granite is nearly complete."

With the granite the course of events has been in part similar, in part quite different, depending upon the amount of jointing. Where the granite is deeply fissured, the rock is quickly broken to fragments of varying size, and these, falling from place, are soon reduced to coarse sand, often deeply colored with iron. Where the

joints are horizontal the peaks have a terraced appearance, as on the south flank of Pyramid Peak. The sandy slopes formed from the crumbling granite are very pervious to water, and on their higher reaches only such plants as have especial advantages in obtaining a requisite amount of water can survive. At their bases one finds a distinctly mesophytic association, for the water absorbed above oozes out below and may be of amount sufficient to cause marsh conditions. On the east side of Angora Peak is such a sand slope whereon the plants become progressively more mesophytic as the foot is neared. Since the soil is the same from top to bottom, except for the increasing amount of organic material present, such a slope seems to be a direct, though imperfect, gauge for the water factor in plant life.

Where the granite is massive the process of rock decay is entirely different. While the factors concerned (temperature and moisture) are the same, their action is largely neutralized by the lack of rock fissuring; rock decay becomes almost entirely a matter of exfoliation. Huge slabs become broken from the surface and by their position protect the rock beneath; only as the slabs are slowly broken and slide from place can the process continue. In the granite deserts of Desolation Valley, Rubicon Valley, and Donner Pass, this protecting action of the exfoliated slabs may be particularly well seen. Here the only spots capable of bearing a flora are the small depressions between the glaciated ridges with soil formed in large part of wind blown granite dust. Over the greater surface plant life is impossible save for crustose lichens and a few hardy crevice plants, which have settled in the fissures about the borders of the slabs.

Limestone seems to be lacking in the district, though so abundant and important a rock base of the Basin ranges.

The rocks derived from extrusive lavas are mainly andesites and basalts. The principal vents, from which these flows issued, lie on the crest of the so-called Great Western Divide. From Round Top Peak, some 30 miles south of Lake Tahoe, there is a succession of ancient volcanoes terminating in Castle Peak, northwest of Truckee. The chief center for these flows seems to have been Mt. Mildred (2), 10 miles west of Lake Tahoe. These irruptives

now commonly lie on the top of ridges overlying the schists and granites. On decay they produce a dark red soil, over which are scattered angular or roughly rounded gray or brown andesite boulders.

The basalts, which locally may be present in considerable amount, lie above the andesite, which frequently shows a metamorphosed condition due to the heat and pressure; on the summit of Mt. Tallac is such a contact. These basaltic irruptives are the

FIG. 1.—Transition zone: pond vegetation with climax forest; Mount Tallac in the distance.

most recent general feature of the geology, and the time intervening to the present has not been sufficient to materially modify the flows.

The whole district, except the highest summits, has been subjected to severe glaciation. This occurred in the later part of the Pleistocene, and the interval since has been too short to obscure the evidences of ice action, particularly at the higher levels where the surface was swept bare. Today these barren areas lie exposed, practically destitute of soil, and constitute some of the most striking evidences of glacial action to be found in the Sierra. At the time of maximum ice the higher levels were all filled with névé

fields which fed the glaciers moving down the valleys, transporting the débris that now forms the morainal heaps at 6000–7000 feet. The peaks and ridges, left after the débris was carried away, show many typical features of glaciated mountains: cirques, aretes, dents. A most perfect example of the last is Pyramid Peak, on whose north slope the Rubicon Glacier had its source, thence moving north, scouring out Rubicon Valley and probably debouching into Lake Tahoe through Rubicon Pass (7150 feet) and the valley of McKinney Creek.

Ice action varied in its effect upon the relief with the several rocks beneath the surface of the glaciers; in the andesite the glacial sapping is especially marked and the cirques of Twin Peak and Mt. Tallac are excellent examples of their kind. On the massive granite the effect seems to have been practically limited to clearing away the loose material overlying the bed rock, which was little, if at all, affected.

Topography

The region studied is embraced within the area mapped by the United States Geological Survey on the Truckee and Pyramid Peak quadrangles. It is roughly some 50 miles long and 15 wide, and may be considered as a typical section of the Central Sierra. This section of the range does not contain elevations comparable to those further south in the High Sierra of Fresno and Tulare counties, nevertheless several of the peaks rise above 10,000 feet, and one, Freel's Peak, is over 11,000 feet. The area is in shape a trough, with average elevation of the floor about 6500 feet. The rim of the trough is formed on the west of the Great Western Divide, which separates those streams flowing westward to the Great Valley of California from those forming a part of the Great Basin drainage system. The eastern margin is the Carson Range, the most eastern of the Sierran ranges.

The Great Western Divide is the more deeply dissected of these limiting mountain chains. From Round Top (10,430 feet) in Alpine County this dividing ridge runs north to Echo Lake and then bears west of north, continuing beyond Mt. Lola (9167 feet) into Sierra County. Along this height of land the more promi-

nent peaks are Mt. Tallac (9785 feet), Rubicon Peak (9193 feet), Twin Peak (8924 feet), Tinker Knob (9020 feet), and Castle Peak (9139 feet). The average height of the ridge is above 8000 feet. To the west it falls by a gradual slope to valleys draining into the Yuba, American, and Cosumnes rivers. Its eastern side forms an abrupt scarp closely skirting Lake Tahoe and the valley of the Truckee River. From the lake this scarp appears in places to be almost sheer. From the summit of Mt. Tallac there is a descent

FIG. 2.—Canadian zone: the high summit is Pyramid Peak

of over 3000 feet in less than two miles. There is some reason to think that fairly uniform elevation of the ridge really represents the remnant of an ancient plateau, traces of which still persist on the south side of Mt. Tallac and Angora Peak. It has been suggested (1) that the summits themselves represent a still older erosion surface, but for this there is little direct evidence. This summit accordance is a general feature of the Sierra, particularly marked in the High Sierra (3). On this ancient upland lie the high alpine valleys, of which Faith, Hope, and Charity valleys south of Lake Tahoe are typical.

The Carson Range, of which Freel's Peak is the highest summit, is less rugged than the Divide. Its summits are rounded or

even flattened cones, though the second highest peak, Mt. Rose (10,800 feet), has a steep ascent to the top. Its much more gentle contours are no doubt due to receiving far less rainfall than the Divide, and to the erosional force being consequently many times less.

Between these limiting ranges the drainage all centers in the Truckee River. The Upper Truckee rises north of Round Top, enters Lake Tahoe east of Tallac and, as the Truckee River, emerges from the northwest corner of the lake. Its course is north to the point of union with Donner Creek and then northeast through the Truckee Canon to the floodplains about Reno, Nevada. All of its important tributaries enter from the west, having their sources in the Divide's many lakelets.

These alpine and subalpine tarns are among the greatest charms of the region. They commonly fill the glacial cirques and often form a series of small basins from whose lowest margin the connecting brook cascades to the major stream. These pools are being gradually silted up both by sediment washed in from the adjacent slopes and by the vegetation fringing the banks; in time they become marshes and finally meadows, which in turn yields to the forest, for, as shown below, the forest is in this region of the Sierra the ultimate phase, since the elevation is not great enough to cause a cold timber line. On the broad ridge between Gilmore Lake and Suzy Lake above Glen Alpine is such a series of nearly filled basins, the largest of which is already converted into a marshy meadow, on whose margin a young growth of lodge pole pine, has started.

As these lakes are mainly in glacial basins, they are frequently banked on the low side by moraines, which in places become of major importance in the local topography. The glaciers of the region have formed large deposits as lateral and terminal moraines about Independence and Donner Lakes, and on the west shore of Lake Tahoe an ancient extension of the last has been cut off by several terminal moraines of the Fallen Leaf Glacier and now persists as a separate lake, three miles long. The moraines on the sides of this lake are especially large, the eastern one being as long as the lake and 900 feet high.

Some of the valleys through which the larger glaciers moved have the U-shaped cross-section characteristic of glaciated moun-

tain valleys, a form very different from the V-shaped canons on the west side of the Divide, and also differing from the lower reaches of Truckee River into which the ice seems not to have entered. A typical example of such a U-shaped valley is the depression once filled by the Fallen Leaf Glacier and now having for its center the channel of Glen Alpine Creek.

Climate

In attempting a sketch of climatic conditions in the high Sierra, one is confronted with the fact that exact observations are too few

FIG. 3.—Canadian and Hudsonian zones: Suzy Lake with Dick's Peak at right

to justify anything more than provisional statements. The data offered for the several stations have been gathered from the reports of the Weather Bureau; since detailed statement for the highest station has only been published since 1906, it has seemed best to make comparisons cover the same years even for stations where data of a kind is obtainable through a longer period.

The most constant feature of the alpine climate is the diminishing pressure with ascent. While there is little evidence to show that this factor is of itself important in the life of plants and animals, at least within the vertical range of the mountains of western North

America, yet it induces change in other climatological factors which are of great importance. "Le fait essentiel d'où dérivent à peu près tous les caractères du climat de montagne est la raréfaction de plus en plus grande de l'air dan les hautes altitudes. De tous les phénomènes météorologiques des régions élevées, c'est le plus régulier, car c'est le seul qui ne dépende pas des conditions locales du relief" (4). Among these changed factors may be mentioned increased insolation, increased radiation, change of illumination by increase of proportion of violet light, and rapid alteration from saturation to extreme dryness (5).

That any considerable ascent is accompanied by a fall of temperature is a constant phenomenon all the world over; it is due to the diminished heat capacity of the rarefied air. This fall in temperature may be counteracted within narrow limits by the relief; it is frequently noted in the mountains that plants which are indicators of a colder habitat are growing at a lower elevation than other plants commonly found much lower down. This is especially true in lately glaciated regions with their usually rugged topography; the cirques will often have a flora distinctly microthermic, while the surrounding ridge bears forms suggesting a milder climate. An example of such a contrast is afforded by the cirque on the northeast of Mt. Tallac, in which *Tsuga Mertensiana* is growing full 500 feet below *Pinus Jeffreyi* on the bluff overlooking Fallen Leaf Lake. This inversion of temperature, with the colder air sinking to the valleys and the warmer currents sweeping up the ridges, accounts in part for the lingering snow drifts that may lie in the cirques till late in the summer, or even persist throughout the season. It also produces a complexity in zonal maps, the limits of the warmer zones advancing up the slopes and the colder sinking below their average level.

In the higher Sierra low temperatures in winter are known comparable to those of the east. The lowest temperature reported from Tamarack, Alpine County (8000 feet), is −29°F. in January, 1910, or 51° of frost. On the summit of Mt. Rose the lowest record is −10° F. Summer temperatures may become fairly high; Tamarack reports 86° F. in July, and Summit, Placer County (7017 feet), 90° in October (table B). This last suggests a new feature

of the alpine climate: the displacing of the heat total toward the end of summer and fall. The start of the vegetative period (the local "spring") is delayed till summer is well advanced below, but the brilliant insolation of the alpine day in part compensates for this late beginning, so that "fall" phenomena are nearly contemporaneous both above and below. "Die Primeln blühen auf dem Rigi bei 1800 m. ca. 6 Wochen später als in Zürich, die Herbstzeitlose dagegen beinahe gleichzeitig" (**6**).

FIG. 4.—Hudsonian and Arctic-alpine zones: Desolation Valley at Lake LeConte and Pyramid Peak.

It has been stated that the zone of maximum rainfall in the Sierra is between 5000 and 7000 feet: Colfax (2421 feet), 46.64 in. per year; Cisco (5939 feet), 49.68 in. per year; Summit (7017 feet), 46.58 in. per year (mean of 30 years); but the diminished rainfall at Summit may be due to the influence of the arid east, an influence not barred by high ranges. A comparison of the same period (1909–13) shows at Summit (7017 feet) 40.98 in. mean total precipitation, and at Tamarack (8000 feet) 52.77 in. It will be noted that this would seem to have been a period of less than normal rainfall, the deviation amounting to 12.3 per cent. If such was the case, the precipitation at Tamarack should normally

be 59.24 in. On the eastern side of the Great Western Divide the precipitation falls rapidly, Truckee (5218 feet) having but 26.98 in. (table C).

Most of the annual precipitation in the high Sierra falls as snow and some astonishing totals are recorded from the Tahoe region. At Summit, in the winter of 1889–90, 776 in. of snow fell, or nearly 65 feet; in a record of 38 years the average was 417 inches (7). In the period limited by the winters of 1908–09 and 1911–12, the average annual snowfall at Tamarack was 515 in., at Emigrant Gap (5221 feet) 249.3 in., and at Glenbrook, Nevada, on the east shore of Lake Tahoe, 208.2 in. This last station, elevation 6282 feet, at the western base of the Carson Range, suggests the aridity of that range as compared to the Divide. At Summit on May 10 there is still a mean depth of snow of 20 inches, nor is the land fully cleared in average years till May 26. At Tamarack the end of June still sees the ground covered every other year. Severe frosts may occur at any time throughout the summer, but the rubric "killing frosts" of the weather reports is inapt when applied to the high mountains, for the simple reason that the plants may be frozen but are not killed. I saw on a morning in August plants of *Gentiana calycosa* stiff and brittle with frost on the shoulder of Mt. Tallac, yet in the afternoon the same colony was apparently none the worse for the freeze (table D).

This great burden of snow acts upon the plants of the district in at least three ways: it furthers tree growth, but impedes the growth of the forest; it favors the meadow, and particularly the wet meadow; it favors summer ephemerals.

In the Tahoe region at present there is no glacial ice, and but few snow banks persist for longer than one season. Where these occur, they are always on the east or northeast of the ridges and peaks, for the prevailing wind from the southwest piles up the snow on these exposures. No true snow line exists.

Alpine winds are keen and drying, and, in spite of their actually moving smaller masses of air, exert a marked influence upon the forms of plants. "Wind cripples" are a constant feature of the arboreal vegetation on the higher summits. On Mt. Rose velocities of 50 miles an hour have been recorded. In the spring a

"chinook" wind quite commonly melts the snow very rapidly. Beside these general winds, mention should be made of the so-called "mountain and valley" winds which reverse their movement twice daily, flowing down the valleys at nightfall and attaining considerable force when the valley narrows suddenly below, and flowing toward the summits when these have been heated by the morning sun. These winds are of moment in alpine plant distribution as being probably among the most effective agents for extending the vertical limits of species.

TABLE A

MEAN MONTHLY AND ANNUAL TEMPERATURE (F.)

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Truckee 5818 ft...	25.3	28.3	32.9	40.0	48.4	57.4	65.4	63.4	55.9	45.1	36.5	28.7	43.9
Summit 7017 ft...	26.8	27.7	32.0	35.9	44.6	51.2	57.6	58.0	53.8	46.5	34.8	28.0	41.4
Tamarack 8000 ft..	21.5	21.7	26.8	32.5	36.5	45.8	55.2	56.3	48.1	39.1	29.8	19.8	36.1

TABLE B

MONTHLY EXTREME TEMPERATURES*

	January			February			March			April			May			June		
Summit..	55	− 4	35	52	− 8	46	53	6	31	71	− 2	30	85	12	39	82	28	43
Tamarack	49	−29	64	53	−25	64	64	−17	54	69	−14	58	81	6	46	80	18	50

	July			August			September			October			November			December		
Summit..	86	28	47	89	27	48	88	28	48	90	20	50	69	8	36	55	− 5	28
Tamarack	86	24	47	82	30	48	80	20	50	76	2	49	62	− 8	48	58	−20	52

*Under each month the first column gives the highest temperature ever recorded at the station; the second, the lowest temperature; and the third, greatest daily range ever recorded in the month.

TABLE C

TOTAL PRECIPITATION IN INCHES 1909–1913

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Summit	13.58	3.22	6.22	2.69	1.17	0.07	0.97	0.03	1.0	0.85	4.94	6.24	40.98
Tamarack	16.85	5.08	4.74	3.39	1.78	2.40	1.5	0.31	1.12	1.75	6.69	7.16	52.77

TABLE D

SEASONABLE SNOWFALL IN INCHES

	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	Year
Summit.....	T	6.2	38.7	52.2	166.2	47.2	62.0	23.5	12	408.0
Tamarack.....	1.0	16.6	55.1	60.5	198.7	76.2	51.5	36.5	18	496.1

Life zones

TRANSITION ZONE.—The problem of attempting to discover the zonal limits of the various species collected in the Tahoe region is complicated by the very irregular topography; the line between adjacent zones is nowhere clearly defined, and, where the relief is especially rugged, often becomes very tortuous. Mapping can only express the general distribution, at least on maps of such a scale as are available. In addition to the complication caused by the relief and consequent frequent change of exposure, the soil characters cause a variableness in the zone boundaries; on the dark chocolate colored trap lives a flora whose members are distinctly more xerophytic than those of granite soils. A very evident change of plant life, for which this edaphic factor seems the only one assignable, is that found on the ridge connecting Suzy Lake with the mountain group culminating in Dick's Peak. The ridge runs northwest to southeast and the south slope is fairly even, but where the trail runs out of the granite into the trap a break in the general aspect of the flora occurs: typical Upper Transition on the granite with *Abies concolor* and *Pinus Jeffreyi* as the chief trees, and Canadian on the trap with *Juniperus occidentalis* giving the tone to the forest.

Another more difficult factor in the problem of assigning plants to definite zones is the fact that the plants often refuse to be so assigned; the stragglers from the general rank are too numerous. Yet in spite of this it seems desirable and feasible to group the vegetation within certain altitudinal categories and, while many individuals of a given species will be often found outside the zone of their greatest frequency, as a whole the assemblage of plants denominated the "Transition flora of the Sierra" has a general coherence, and the expression conveys a definite meaning to those who have considered the whole Sierran flora.

In the Tahoe region this Transition flora covers approximately 25 per cent of the total area, which is equivalent to saying that by far the larger part of that flora lies below the region considered in the present report, and we are here dealing with that fraction of the total which has been called Upper Transition, a flora showing more relationship to the life zones above than to those below. It is this fact of alliance with strictly alpine and subalpine floras that requires us to consider it here.

The Upper Transition forest, as of all the higher zones, is exclusively a coniferous forest; what few arboreal or arborescent angiosperms are present are only found close to streams or lake shores and hence are to be regarded as members of the stream bank association. This Transition coniferous forest is formed by *Abies concolor*, *Pinus Jeffreyi*, *Pinus ponderosa*, *Libocedrus decurrens*, and *Pinus Lambertiana*, in frequency in approximately the order named. The forest growth is dense in but a few favored localities, as on the floor of the ancient Fallen Leaf Glacier at the south end of Fallen Leaf Lake. Generally the trees are scattering and individual trees relatively small compared to the average size of the same species on the western slope of the Sierras. The white fir alone maintains its average form. The sugar pine is scarce, since in the district the moderately moist rich flats frequented by this tree commonly lie above its range. The yellow pine is a common tree about Tahoe and northward to Truckee, but is dwarfed in size, and appears excessively parasitized by *Arceuthobium occidentale*. At the south end of the lake the nearly allied species *Pinus Jeffreyi* makes with *Abies concolor* two-thirds of the forest cover. As a rule, the woods away from the streams are free from underbrush, the surface vegetation consisting of low perennials mainly, such as *Corallorhiza Bigelovii*, *Pyrola asarifolia incarnata*, *Pterospora Andromeda*, *Pedicularis semibarbata*, *Antennaria argentea*, *Antennaria Geyeri*, and in sunny glades *Balsamorhiza sagittata*, *Erigeron divergens*, and *Madia exigua*.

Next to the forest in importance in the general aspect of the Transition flora comes the stream bank association, which advances up all the water courses, cutting the coniferous forest into isolated fragments. In this stream bank vegetation *Populus trichocarpa*, *Populus tremuloides* (there is a charming aspen grove on the low

shelf just east of Fallen Leaf Lake), and *Salix lasiandra* form the superior stratum, and beneath them grow *Alnus tenuifolia*, *Rubus parviflorus*, and *Cornus pubescens* as undershrubs, while the herbs most frequently found are *Carex rostrata*, *Allium validum*, *Habenaria leucostachys*, *Thalictrum sparsiflorum*, *Cicuta vagans*, and *Heracleum lanatum*. The lowest stratum, made up of delicate herbs for the most part, shows *Listera convallarioides*, *Polygonum Douglasii*, *Kelloggia galioides* (which is also found in the forest), *Galium bifolium*, and *Anaphalis margaritacea*.

Scrub (chaparral) becomes of considerable importance on dry sunny slopes in the Tahoe Upper Transition; the principal species are *Amelanchier alnifolia*, *Cercocarpus ledifolius*, and on sandy benches *Artemisia tridentata*, the last being present as a considerable factor in all the zones below the true alpine. Among these shrubs one finds *Lilium Washingtonianum*, *Eriogonum nudum*, *Collomia tinctoria*, *Mimulus Breweri*, *Mimulus leptaleus*, and *Mimulus Torreyi*.

When the relief becomes too sharp and the soil covering too scanty for chaparral shrubs, there is found a flora of rocky outcrops and benches, composed of small perennials and annuals. Here grow *Eriogonum Douglasii*, *Oxytheca spergulina*, *Heuchera rubescens lithophila*, *Apocynum androsaemifolium*, *Gilia pungens*, *Cryptanthe affinis*, a form of *Monardella odoratissima* (*Madronella pallida* Heller), *Adenostegia tenuis*, *Chrysopsis hispida*, and *Sericocarpus rigidus*.

The meadow formation is well developed along Truckee River, about Donner Lake, and where the Upper Truckee enters Lake Tahoe both east and west of Tallac. Almost exclusively it is a wet meadow, since the dry meadow is speedily invaded by trees and grows into the climax forest. Such an invasion and young forest growth is now taking place just back of Tallac, *Pinus Jeffreyi* seedlings being the chief entrants. On the wet meadow are *Sparganium simplex*, many carices (*Carex lanuginosa* here below its average level, *Carex nebraskensis*), *Juncus nevadensis*, *Veratrum californicum*, *Urtica gracilis*, *Delphinium decorum patens*, *Trifolium cyathiferum*, with *Trifolium pratense* and *Trifolium repens* as immigrants into the meadows about Donner Lake, *Hypericum*

Scouleri, *Agastache urticifolia*, and *Solidago elongata*, the two last being especially common about meadow borders within the ring of *Salix macrocarpa argentea* that commonly hedges the wet meadow. The dry meadow formation, as stated above, is less evident, but still exists and shows a considerable list of species: *Sporobolus depauperatus*, *Zygadenus venenosus*, *Myosurus apetalus*, *Hosackia americana*, *H. crassifolia*, *Gomphocarpus cordifolius*, *Allocarya hispidula*, *Cryptanthe geminata*, and *Aster canescens* being the more numerous.

CANADIAN ZONE.—Of the several life zones discoverable in the Tahoe flora, the Canadian is at once the most extensive and most difficult to define. Its lower limit conforms generally to the 7000 feet contour line, while the upper boundary may be placed at about 8500 feet as a maximum; within this range of 1500 feet lies the greater part of the district. This zone includes most of the ridges connecting the peaks rising into the alpine region; it covers the lower flank of the Divide, and encircles Mt. Rose below 9000 feet, for in the Carson Range the greater aridity and higher mean temperature of the growing season causes all the life zones to rise higher than they do in the mountains west of Lake Tahoe. This rise of the zonal limits reaches a maximum on Freel's Peak, which has small groves of *Pinus Murrayana*, perhaps the one best "Leitpflanze" of the Canadian flora, even at the 10,000 feet level. These slopes are frequently composed of loose granite sand, and, as mentioned in the case of the slope east of Angora Peak, support a characteristic flora of shrubs rarely found outside the Canadian life zone. The edaphic factor must be constantly kept in mind in locating zonal limits, and in our district this is largely conditioned by the degree of glaciation and subsequent erosion. Where the country rock was swept bare, a typical Hudsonian assemblage of plants is apt to be found, even though well below the 8500 feet limit, as in Desolation Valley at 7800–8000 feet. Where deposition has given a sufficient soil cover, conditions are decidedly ameliorated, and the Canadian flora develops typically even above its general level, as in the high alpine valleys south of Lake Tahoe.

The Canadian forest is, for the most part, a thin forest; as a rule the trees stand well apart, only exceptionally preventing

sunlight reaching the ground in quantity insufficient for a varied herbaceous ground flora. This in effect brings the meadow into the forest, or rather the forest into the meadow, since the last is antecedent to the climax vegetation of the district, the coniferous forest. There is then difficulty in describing these associations apart, though they are distinct enough below.

The one tree of this forest which usually forms dense stands is the red fir (*Abies magnifica*). It favors low benches and bottoms of valleys and is not often found upon the slopes save as a fringing forest along water courses. It does form a considerable element in the forest on the great moraines, however, the loosely aggregated soil of which permits deep root penetration. On the great moraine east of Fallen Leaf Lake the red fir is the principal tree. This dark fir forest has few shrubs, but does support a characteristic flora of ericaceous perennials, such as *Pyrola pallida*, *P. picta*, *Chimaphila Menziesii*, *C. umbellata*, and *Sarcodes sanguinea*. The fir forest is an exclusive association, few of the other Canadian species entering into it, doubtless excluded by the insufficient light for seedlings.

The Canadian pine forest has a very different aspect, being open or even parklike in the spacing of the trees. Neither of the two pines which compose it (*Pinus Murrayana* and *Pinus monticola*) attain large size, but are widely branching, especially at their upper levels. *Pinus monticola* continues into the Hudsonian and at times becomes a tree line form, but *Pinus Murrayana* is relatively constant about Lake Tahoe as a Canadian exemplar. The lodge pole pine is a vigorous seeder, and all about the meadows in the Canadian, where drainage has permitted, the young seedlings form a dense border. By subsequent drying out of the weaker individuals the open character of the mature forest is attained. *Pinus Murrayana* is often attacked by *Arceuthobium americanum*.

Within this open forest grow several shrubs: *Salix Scouleriana* along the damp ravines, and with it *Vaccinium occidentale*, *Ribes cereum*, *R. nevadense*, *Purshia tridentata* (this forming rounded clumps which in the Hudsonian become dense polsters), and above all as a typical undershrub, *Ceanothus cordulatus*. The herbaceous flora embraces *Melica aristata*, *Spraguea umbellata*, *Stellaria Jamesiana*, *Lupinus calcaratus*, *L. apertus*, *Viola Nuttallii*, *Ortho-*

carpus cryptanthus, *Aster integrifolius*, *A. yosemitanus*, *Erigeron inornatus*, and *Senecio lugens*.

The other tree found commonly in the Canadian is the Sierra juniper (*J. occidentalis* Hook), which in the Tahoe region is confined exclusively, so far as I could determine, to the slate outcrops, never appearing on granite in this lowest of the boreal zones. It often attains large girth at base (one measured on the Dick's Peak-Suzy Lake trail was 16 feet in circumference), but branches low and reaches a height of 20–25 feet. At Camp Agassiz, at the lower limit of the Canadian, it is parasitized by *Phoradendron juniperinum*.

The Canadian scrub (chaparral) is a constant feature of the vegetation on the dry rocky hillsides: *Amelanchier alnifolia* and *Cercocarpus ledifolius* continue up from the Transition and are associated with *Amelanchier glabra*, *Holodiscus microphyllus*, *Ceanothus velutinus*, *Arctostaphylos patula*, *A. nevadensis*, and *Grossularia Roezli*. On these dry slopes among the shrubs are found *Silene Douglasii*, *Gayophytum ramosissimum*, *Zauschneria californica*, *Chaenactis Douglasii*, and *Eupatorium occidentale*. On the slopes where the weathering has reduced the rock débris to finer particles we find at the top sedums deeply rooted in the loose sand (*Sedum obtusatum* and its close ally *Gormania Burnhami*), and below, where the influence of the water content of the slope becomes appreciable, bordering thickets of *Acer glabrum* (*Acer Torreyi* Greene), *Sorbus californica*, and below these, *Prunus emarginata*. *Spiraea arbuscula* occurs at the base of such slopes where the water supply is abundant.

The true rock plants include *Quercus vaccinifolia*, the only oak of the boreal region, which forms dense espaliers over rounded rock surfaces, but is more evident as a cover for the roches moutonnées in the glaciated Hudsonian valleys. This shrub seems to be restricted to the granite at Lake Tahoe. *Nama Lobbii* is a plant of similar habit and covers many granite boulders about Cisco. Other rock-plants are *Eriogonum Lobii*, *E. umbellatum*, *Sedum stenopetalum* (the last forming extensive patches), *Lupinus Breweri* (a typical dry lithophyte), *Apocynum androsaemifolium pumilum*, *Pentstemon Jaffrayanus*, *P. deustus*, and *Hieracium horridum*. The xerophytic ferns *Pellaea Breweri* and *P. Bridgesii* are common on the trap outcrops, while another rock fern of similar habit, *Woodsia scopulina*, was seen but once.

The series of hydrophytic associations begins with plants of lakes and pools. Of these in the Tahoe Canadian are present about the edge of the basins *Nymphaea polysepalum*, *Callitriche verna*, *Hippuris vulgaris* (very abundant in Lily Lake near Glen Alpine), and the buckbean (*Menyanthes trifoliata*). These plants of the open waters in decaying advance the margin of the land into the water; in their wake appears *Carex spectabilis*. The drying margin supports a growth of willows (*Salix californica*, *S. Lemmonii*, and at the higher levels *S. sitchensis*), while beneath them grow *Ranunculus flammula reptans*, *Cheiranthes asper*, and in such an evironment in one locality was found *Botrychium californicum*.

The ultimate end of such an invasion is the filling of the lake and beginning of the wet meadow association, which about Lake Tahoe in the subalpine includes *Sparganium simplex*, *Sagittaria latifolia*, *Carex aurea*, *Juncus bufonius*, *Veratrum californicum*, *Spiranthes Romanzoffiana*, *Ranunculus alismaefolius alismellus* (continues into Hudsonian and alpine), *Hosackia Torreyi*, *Hypericum anagalloides*, *Veronica humifusa*, *Helenium Bigelovii*, and allied forms.

On the drier edge of such swampy meadows are found *Agropyron divergens*, *Phleum alpinum*, *Stipa occidentalis*, *Tofieldia intermedia*, *Polygonum aviculare*, *Saxifraga integrifolia sierrae*, *Frasera speciosa*, *Pedicularis attolens*, *Arnica mollis*, and *Erigeron salsuginosus*, the last being more abundant in similar localities in the Hudsonian. About the edge of such meadows and along their drainage channels will be found *Salix macrocarpa argentea*, *Cornus pubescens*, and *Alnus tenuifolia*, the last a characteristic Canadian shrub of stream banks.

When the drainage has progressed beyond the wet meadow stage, such plants as *Melica fugax*, *Phleum pratense*, *Stipa viridula*, *Allium campanulatum*, *Calochortus Leichtlinii*, *Polygonum imbricatum*, *P. Kelloggii*, *Lupinus sellulus*, *Epilobium brevistylum*, *Gilia Harknessi*, *G. ciliata*, *Erigeron Breweri*, and *Gnaphalium palustre* appear to be followed by seedlings of the lodge pole pine and the ultimate forest phase.

The third distinctive association, that of the fringing vegetation of stream channels, includes such plants as *Habenaria sparsiflora*, *Aconitum columbianum*, *Aquilegia truncata*, *Delphinium glaucum*,

Sphenosciadium capitellatum, besides the willows and the alder above named.

HUDSONIAN ZONE.—This zone in the generally accepted scheme of zonal arrangement ends at tree line; it ought then by hypothesis to be a simple matter to distinguish the upper limit. Unfortunately, tree line is conditioned by so many factors, any one of which may be decisive at any particular place, that in the field it is often nearly impossible to define the line that separates the last of the forest zones from the true alps above. In the Tahoe district this is all the more true since, as stated above, a *cold* tree line seems not to exist. The factors that impede and ultimately prevent tree growth are in our district wind currents, edaphic conditions, and the mechanical effect of deep snow.

The formative influence of wind upon tree growth is apparent enough at low levels; trees near a beach are commonly strongly modified in shape, but in this case the mechanical effect of the wind seems to account for much of what is observed. At high latitudes and on high mountains the wind appears to exert the same stress plus a drying out power which the tree cannot withstand. In the Tahoe region it is this desiccating wind that most often determines the limit to the forest; on one side of an aréte tree growth will dwindle out scores, even hundreds of feet below the summit, while on the other side trees of normal shape rise to the top. As the wind is prevailingly from the southwest, trees on a north slope ought to rise higher, other conditions being equal. This they do in a few cases, as on the north side of the aréte above Gilmore Lake, connecting Mt. Tallac and Jack's Peak. More often the sheltering effect of the ridge is discounted by the deep snow drifts which the southwest wind drops on the north and east sides of the peaks and ridges. In the glacial cirques on the east side of the Divide one commonly finds trees growing up to the chord of the arc, rarely within the cirque itself, and the inference seems warranted that this tree line is a deep snow line. Quite as often the tree line is a product of the soil conditions; trees cannot grow on the unfractured rock, and where this is massive and exposed a tree line exists; this is the explanation of the treeless Rubicon Valley. A limit to the growth of trees is also set by an excess of ground water; many of the peaks and ridges about Lake Tahoe

are unwooded at their summits because of wind conditions; their sides are compassed by heaps of talus more or less fragmented, but not affording a footing for the seedling pine or fir, while below these rubble heaps marsh conditions prevail due to the seepage of water from the slopes, and the trees are kept at a distance. All of these factors, either singly or combined, operate to make the line a very sinuous one that divides the true alpine region from the Hudsonian forest.

In that forest the principal trees are the white bark pine (*P. albicaulis*), the silver pine (*P. monticola*), the Sierra juniper, and the alpine hemlock (*Tsuga mertensiana*). The first is the tree line tree of the Sierras par excellence, being found along the whole Sierran crest. In the Tahoe region the largest forest of this pine is on the southwest flank of Mt. Tallac; here it forms a nearly pure stand and decreases from a tree 40–50 feet in height to prostrate wind cripples at the base of the actual peak. The finest examples of single trees noted grew on the plateau between Angora Peak and Ralston's Peak. *Pinus monticola* is not common in the south end of the Tahoe district, but increases northward about Cisco. The Sierra juniper (*J. occidentalis*) appears to have an interesting distribution about Tahoe; in the Canadian it is always found on the slate outcrops, but in the Hudsonian seems to be the chief krummholz tree of granite basins. It was not noted on the higher lying volcanics (andesites). The chief groves of the alpine hemlocks in the region are on the Lucile Ridge and in Desolation Valley, where along the east side of the valley it forms a pretty continuous forest for several miles. Unlike the forest of white bark and silver pines, the hemlock forest is dark and the ground flora sparse. In the more open pine forest the ground cover is made up in part of *Polygonum Davisiae*, *Fragaria virginiana platypetala* forma *sibbaldifolia* Hall, *Lupinus Lobbii*, *L. meionanthus*, *L. montigenus*, *Epilobium obcordatum* (the last on the higher ridges), *Hieracium gracile detonsum*, and *Whitneya dealbata*. About the edges of the hemlock forest were growing *Aster Andersoni* and *Artemisia norvegica*.

Above the forest, rising toward the peaks and arêtes, are extensive talus slopes, and higher still the country rock offers on ledges and in crevices lodgement to many plants of peculiar habit and extraordinary adaptation to their inhospitable surroundings. It is

on this rocky surface that one finds many of the growth forms associated with extreme life conditions: polsters, mat plants, espaliers. It is this region of the high mountains that offers the closest analogies to the forms of desert plants, and it is here that some of the peculiarly desert genera (such as *Eriogonum* and *Artemisia* among flowering plants, *Cheilanthes* for desert ferns) have made their deepest mark upon the alpine flora. Conditions on the broken talus are quite different from those of ledges, and a different group of plants grows on it: a high altitude dwarf chaparral formed of *Ribes montigenum*, *R. viscossissimum Hallii*, *Grossularia lasiantha*, *Purshia tridentata*, *Aplopappus macronema*, and *Artemisia arbuscula*. These may all grow intricately together, or separately, when all assume the same growth form, hemispherical polsters. On the more solid rock the mat form is the more common (*Spraguea umbellatata*, *Phlox Douglasii diffusa*, *Chaenactis nevadensis*). In crevices will be found *Eriogonum marifolium*, *E. Wrightii*, *Gilia congesta palmifrons*, *Polemonium pulcherrimum*, *Eriophyllum integrifolium*, and *Senecio canus*. Over the glaciated granite surfaces exposed in Desolation Valley *Quercus vaccinifolia* forms dense espaliers. On the granite also was found the only specimen seen of the arctic-alpine shrubby cinquefoil, *Potentilla fruticosa*. On wet granite ledges grow *Scirpus criniger*, *Sedum integrifolium*, *Parnassia californica*, and *Erigeron Coulteri*. Where a soil cover has accumulated on moist ridges are to be found *Cassiope Mertensiana*, *Lappula Cusickii*, and *Pentstemon procerus geniculatus*.

As in the Canadian, so in the Hudsonian pine forest the meadow spreads under the trees and among the grasses (*Agrostis Rossae*, *Festuca scabrella*, *Melica stricta*) will be growing *Brodiaea gracilis*, *Calochortus Leichtlinii*, *Gayophytum caesium*, and *Aplopappus apargioides*. A characteristic feature of high mountain meadows is the large percentage of carices and junci present; in the Hudsonian meadows of Lake Tahoe have been identified *Carex capitata*, *C. Helleri*, *C. luzulaefolia*, *Scirpus pauciflorus*, *Juncus Parryi*, *J. nevadensis*, and *J. subtriflorus*. Common herbs of these wet meadows are *Stellaria longipes*, *Saxifraga bryophora*, *Trifolium monanthum*, *Gentiana Newberryi*, *Mimulus pilosellus*, *Antennaria media*, and *Erigeron salsuginosus*.

Hudsonian lakes are generally fringed by *Salix glaucops*, *Ledum glandulosum*, and *Phyllodoce Breweri;* while along the marshy margins of the outlet will be found *Carex straminiformis*, *Viola Macloskeyi*, *Dodecatheon alpinum nanum*, and *Kalmia glauca microphylla*.

ARCTIC-ALPINE.—A feature of the flora of the boreal region as compared to the Transition is the gradual merging of the forest and meadow due to the thinning out of the former. At tree line the forest becomes zero and the meadow becomes the dominant formation, for in a sense the rocky fields about the summits themselves are inchoate meadows; between the boulders meadow conditions prevail. These diminutive meadows do not differ essentially from the larger expanses below the rock fields. The only formations to dispute the territory are that of rock crevices and the true lithophytes.

As stated above, it is questionable if a true climatic tree line exists about Lake Tahoe; nevertheless certain plants (*Oxyria digyna*, *Ranunculus oxynotus*, *Draba glacialis*, *Juniperus communis sibirica*, *Primula suffrutescens*, *Hulsea algida*, *Ivesia Schockleyi* may be cited) are present, which are constantly found only above tree line in regions where such a line unquestionably exists. In the absence of a better understanding of this vestigial arctic-alpine flora, a discussion at present would be premature.

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ON THE MALE GAMETOPHYTE OF PICEA CANADENSIS

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 200

A. H. HUTCHINSON

(WITH PLATES XV–XIX AND ONE FIGURE)

The male gametophyte of *Picea excelsa* has been described by STRASBURGER, MIYAKE, and POLLOCK. At the shedding stage, as recorded by STRASBURGER (1), there are two disintegrating prothallial cells, a stalk cell, a body cell, and a tube nucleus. MIYAKE (2) verified this account; also described the pollen tube stages and the division of the antheridial cell into stalk and body cells. POLLOCK (3) noted certain variations in the gametophyte at the time of pollination. This account deals with the early stages of development in the male gametophyte of *Picea canadensis*.

The staminate cones were collected from trees growing near Lake Simcoe, Ontario, Canada. Daily collections were made from May 2 until May 15, the time of shedding. The usual time for pollination in this locality is about two weeks later.

Nomenclature

The nomenclature used in accounts of male gametophytes has varied according to the character used as a basis for the system, whether it be size, position, or the writer's conception of origin or function of the different cells. Early in the nineteenth century FITZSCHE described *Pinus* as having a large central vesicle and disintegrating bodies against the wall of the pollen grain (*Zwischenkorper*). MEYEN (in 1839) stated that the *Zwischenkorper* were cells, and that one of them served as a stalk of attachment. JURANYI (4) reported that in *Ceratozamia* the pollen mother cell divided into a large and a small daughter cell (*kleine Tochterzelle*); that the latter divided to form two, and that the inner of these gave rise by division to an inner cell and an end cell. These three cells were collectively known as the cell body (*Zellkörper*). Until 1891 the tube nucleus (*grosse Zelle* or *freigebildete Zelle*) was believed

to be the fertilization nucleus. At that time BELAJEFF (**6**) showed that in *Taxus baccata* the larger cell is not the generative cell; but that the small cell divides in the tube and one of the derivatives becomes the generative cell.

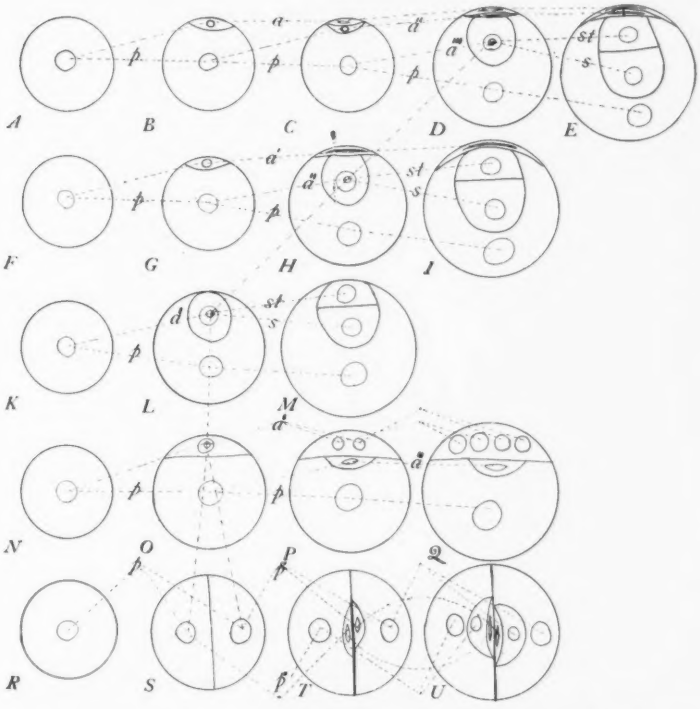
In 1892 STRASBURGER (**1**) described *Ginkgo biloba* as having two prothallial cells, representing a vegetative prothallus, and an antheridial cell, which are successively cut off from the pollen cell; the antheridial cell divides into stalk and body; the latter produces the sperms. The large pollen nucleus, because of its foremost position in the tube, was called the tube nucleus. The general conception of origin and function is the same today. It is not surprising, however, that, with such a variety of types, different investigators have since used different terms to designate similar cells.

The system of nomenclature to be used in this account has been made necessary by the nature of the gametophytic development. The primary cell (*P*) is regarded as retaining its identity, just as an apical cell. In the pollen tube stages it is represented by the tube nucleus. The successive divisions of the primary nucleus are known as primary divisions; the cells cut off are called, tentatively, the first, second, or third primary derivatives (*a'*, *a''*, *a'''* in figs.). Divisions of the latter cells are called secondary. The cell which later divides to form male nuclei is termed spermatogenous (*s* in figs.); the sister non-functioning cell is the sterile cell (*st* in figs.). The mother cell of a spermatogenous and a sterile cell is called an antheridial cell.

Development of the male gametophyte

The first primary division is variable; the cell wall may cut off a lenticular polar cell (fig. 7); it may be oriented at right angles to the longitudinal axis, cutting off approximately one-third of the protoplasmic mass (figs. 6, 33, 37, 53); it may be in the plane of the vertical axis, in which case two nearly equal cells result (figs. 2, 10, 11, 13, 31, 32); it is often inclined (figs. 28, 29); and occasionally no dividing wall is formed, the two resulting nuclei being then free in the cytoplasmic mass (figs. 8, 9, 12). The further development of the resulting cells is largely determined by the

nature of the first primary division. When the primary derivative is small and lenticular, it rapidly degenerates (figs. A-I and 20–26 etc.); when the division is median or nearly so, each of the two cells formed has the power of repeated division, giving rise to a



FIGS. A–U.—A diagram to illustrate five types of development in male gametophytes of *Picea canadensis: P*, primary cell; *a'*, *a''*, *a'''*, the first, second, and third (potentially) antheridial cells; *s*, spermatogenous cell; *st*, sterile cell; the dotted lines indicate origin and sequence; relative size is also shown; figs. A–E, three primary divisions, first and second cells cut off evanescent, third by a secondary division produces a spermatogenous and a sterile cell; figs. F–I, two primary divisions, second cell cut off from primary cell functions as antheridial; figs. K–M, first primary derivative functions as antheridial cell; figs. N–Q, two primary divisions give rise to two antheridial cells, repeated divisions of the first produce four free nuclei; figs. R–U, primary cell divides to form sister primary cells, each of which produces an antheridial group, a bi-antheridial gametophyte.

so-called double gametophyte (figs. R–U and 28, 29, 31, 32); when the first primary derivative is surrounded by cytoplasm it divides, giving rise to a spermatogenous and a sterile cell (figs. K–M and 9, 12, 30). In this case there is no further division of the primary cell; the first primary derivative becomes the functioning antheridial cell. Again, if the first cell cut off contains sufficient protoplasm it may divide once or even twice to form as many as four free nuclei. When this occurs, the primary cell soon ceases to divide and begins to disintegrate (figs. N–Q and 28, 29, 33). The first primary derivative may function as an antheridial cell by directly dividing to form a spermatogenous and a sterile cell, by repeatedly dividing to form a number of free nuclei, or by becoming primary in nature and hence developing along with its sister cell to form a bi-antheridial gametophyte.

When the first primary cell is evanescent, a second primary division takes place. Nor is it uniform. Frequently the primary cell approaches the first primary wall before dividing, and it may come into contact with this wall. The second primary derivative is then cut off as a lenticular cell against the wall of the first and soon disintegrates (figs. C–E and 23, 25, 26). If, however, it remains imbedded in the cytoplasm of the primary cell, it divides to form a spermatogenous and a sterile cell (figs. F–I and 25, 38). Hence the second primary derivative may function as an antheridial cell.

When, as it has been hitherto described, the first and second primary derivatives are evanescent, a third primary division takes place, and the last cell cut off functions as the antheridial cell (figs. A–E and 42–51).

Since the spermatogenous cell may originate from the first, second, or third primary derivatives, we are forced to the conclusion that these cells are all potentially antheridial, one or in some cases two functioning as such. They may be known as evanescent or functioning antheridial cells, as the case may be.

Development; time; nutrition

Growth is exceedingly rapid; in three days the diameter of the pollen grain is doubled, its volume becoming four times as great. In *Pinus* "the mature pollen grain has the same size and form as

the microspore just prior to germination" (**15**). When two evanescent cells are cut off, these divisions take place before the increase in size. They follow one another in rapid succession; all stages of the first two primary divisions are to be found in the same sporangium. A resting period, that is, a period during which mitosis ceases, but during which there is a great increase in size and apparently in food supply, precedes the formation of the functioning antheridial cell, whether it be the first, second, or third primary derivative (figs. D, H, L, O, S and 30, 38, 44, 45). Since this last primary division and the secondary division to form the spermatogenous cell and the sister sterile cell are to be found in the same sporangium, it is evident that they are closely consecutive. The complete development is extremely rapid; on May 3 only one-celled stages were to be found, while on May 6, or sooner, the pollination stage had been reached. Trees on a sunny hillside shed the pollen at once; others retained it for ten days without further development. The functioning antheridial cell is imbedded in the cytoplasm of the primary cell, as shown above, and an increase in the size of the pollen grain precedes mitosis of the former cell. Evidently nutrition is a factor in determining the fate of an antheridial cell; in other words, whether the first, second, or third shall function as such.

Degeneration

In lenticular cells which contain a minimum of cytoplasm surrounding the nucleus, the latter does not pass out of telophase (fig. 26); the chromosomes contract, become globular, and finally disintegrate as irregularly granular masses (figs. 20, 21, 43), or accumulate at the periphery of the nucleus, giving it a vaginated appearance (fig. 45). When these cells collapse, double darkly-stained bands appear in cross-section. In *Picea canadensis* the intine does not imbed these degenerating cells. The first primary wall elongates as the pollen grain increases in diameter (figs. 37, 38, 50, 51); often it has the appearance of a third wall (fig. 50) which is attached to the intine near the origin of the wings. The disintegrating cell contents remain within the original walls; the latter meanwhile become elongated and thickened.

Degeneration may occur in any part of the gametophyte. Frequently the second primary derivative degenerates before the first (fig. 37). If sister primary cells are formed, the struggle resulting from their parallel development is generally so great that disorganization of both results (fig. 32). Usually one gains the ascendency. Often, after as many as three cells have been formed, one of the antheridial groups is crowded against the wall; irregular cavities appear in the cytoplasm (fig. 31); the protoplasm contracts and accumulates in masses of globules; and the nuclei becomes massed or uniformly granular (figs. 33, 53). When an extreme development of the first antheridial cell occurs, the primary cell as well as the secondary antheridial cell may disintegrate (fig. 33).

Mitoses

There are two types of mitoses; that characteristic of primary divisions, and that of secondary divisions. The latter does not differ essentially from ordinary somatic mitoses; the former is quite distinctive in its characters.

The nuclei and chromosomes are decidedly kinetic. Just before mitosis, the primary nucleus moves to a more or less polar position. Frequently it comes in contact with one of the primary walls (figs. 14, 15, 16, 43). There is the usual movement of the chromosomes to form the central plate at metaphase, and the separation of chromosome groups during anaphase. After the two nuclei have been formed, the one which is polar retains its position, while the primary nucleus moves to its central or supracentral position (figs. 5–7; 19–25; 43–45).

The changes in the volume of the nuclear space are very marked. During prophase a slight expansion is followed by a contraction (figs. 14, 15, 16, 28) which continues until the disappearance of the nuclear membrane. The chromosomes at the poles during early telophase aggregate into compact masses (figs. 4, 18, 47, 49); the nuclear membrane is formed, and the nucleus expands until it becomes three or four times its original size. There is an associated accumulation or disappearance of food particles in the surrounding protoplasm. This may be regarded as evidence in favor of LAWSON'S (7) explanation of similar phenomena, namely, that they are due

to osmosis. Moreover, the increase in size is most rapid when the nucleus is surrounded by most cytoplasm; the primary nucleus soon regains the size characteristic of the resting stage (figs. 6, 9, 18, 20, 21).

Chromatic structures

The resting nucleus contains several nucleoli. In early prophase "condensing bands" and "zig-zag threads" of chromatin become differentiated; definite looped chromosomes are formed (figs. 15, 35). Only in rare cases could their double nature be seen at this stage; it would seem that the halves remain rather closely appressed until metaphase. The nucleoli are present until late prophase (figs. 16, 35, 48). The chromosomes contract before aggregating in a definite cell plate (figs. 16, 48); during anaphase they are characteristically V-shaped (figs. 2, 3, 17). In early telophase compact chromatic aggregations are formed (figs. 4, 18, 41, 47, 49). These soon become irregularly vacuolate, and as the vacuoles increase in size, anastomosed bands of chromatin become differentiated (figs. 5, 22, 24, 43). The process is similar to that described by SHARP (**8**) in *Vicia*. The bands become more irregular in outline, and a number of nucleoli appear (figs. 23, 25, 44). As the number of nucleoli decreases, they become individually larger (figs. 20, 45, 6, 8, 46, 48, 50). The irregular bands are replaced by zig-zag threads and the nucleus passes again into the resting condition.

Achromatic structures

The achromatic structures in all primary divisions are most characteristic. The spindle fibers are inconspicuous during anaphase (figs. 2, 3, 36, 42); in many cases they can be distinguished only with difficulty (fig. 17) and are only slightly more definite than the vague radiations in the polar cytoplasm (figs. 3, 36). In early telophase there are very definite strands between the daughter nuclei. These are arranged in the form of a hollow cylinder (figs. 4, 18) which gradually broadens (figs. 19, 43) and moves toward the pole, partly enclosing the antheridial nucleus (figs. 5, 21, 24). Usually the fibers come in contact with the cell wall, the free ends swing outward, and so remain as curved or radiating strands

(figs. 7, 23, 44, 45). The cell plate forms late; it is most definite after the fibers have taken their final position (figs. 6, 7, 8, 41, 45). These mitoses are similar to that described for *Abies balsamea* (9).

The cell plate is evidently associated with the formation of the cell wall. In fig. 45 the arched fibers remain only at one side, but here there is a distinct cell plate and the cell wall is curved outward to meet it. When the wall is formed the fibers disappear. In many cases no cell plate could be seen (figs. 5, 21, 22, 23), and the division in the cytoplasm is continuous with the end of the fibers (fig. 25).

There is abundant evidence that the achromatic fibers are definite structures which change their position. The fact that there are groups of spindle fibers which have no immediate connection with nuclear membranes or chromosomes is further evidence for their individuality (fig. 8).

Secondary divisions have markedly different characters. A polar cap is formed during prophase (fig. 48); the spindle fibers are more strongly developed during metaphase (fig. 38); the cell plate forms early (figs. 47, 49), and the spindle fibers retain their original positions. The similarity of secondary divisions in the first and third primary derivatives is illustrated by figs. 47 and 49.

Chromatic extrusions

In the early stages of the gametophyte, darkly staining bodies occur in the cytoplasm. When the primary nucleus is in the resting stage, these bodies appear as spherical masses surrounded by a clearer area (fig. 34); when the primary cell is in active mitosis these extrusions become fragmented (fig. 35). These bodies originate from wandering chromosomes which escape during mitosis. Separate chromosomes are found near the primary cell wall during metaphase (fig. 36). Evidently these never take part in cell plate formation. They contract into spherical masses and wander into the cytoplasm. In other cases, during late anaphase, several chromosomes prematurely contract to form a more or less compact mass, thereby separating themselves from the chromosomes which later undergo a similar change (fig. 3).

Discussion

1. *Double pollen grains*

There are accounts of double pollen grains occuring in a number of species. Probably first was CHAMBERLAIN'S (**10**) description of *Lilium tigrinum*. "In about 20 cases there was a distinct wall dividing the microspore into two nearly equal parts." Both cells contained starch. His fig. 20 shows one of the cells containing two nuclei "which seem to represent generative and tube nuclei." One of the cells was regarded as prothallial, the other as antheridial. SCHAFFNER (**11**) found compound grains where two or more of the spores of a tetrad clung together (*Typha latifolia*). GUIGNARD (**12**) and Miss PACE (**13**) figure four microspores of an orchid within a common wall dividing to form tube nuclei and generative cells. COKER (**13a**) describes double grains in *Larix europea*. His fig. 6 is similar to my fig. 13; his fig. 8 corresponds to my fig. 12. He suggests that "the mother cell had only divided once, so that only two instead of four pollen grains were formed." In some of these grains "division proceeded as usual except that only one prothallial cell is evident" (cf. fig. 32). POLLOCK (**3**) has described a number of variations in the pollen grain of *Picea excelsa*. "In the material examined, the proportion of double pollen grains was found to be 2.4 per cent in a count of 1120. The three or four cells lying along the dorsal side of the pollen grain of this type do not constitute a prothallium or gametophyte of unusual size. They constitute the smaller portion of a pollen grain separated by a division wall into two nearly equal portions, each of which may form a typical antheridium." Double pollen grains have been variously interpreted. In *Picea canadensis* a study of the stages of development has shown that the two cells from which the double grain arises are the result of a primary division of the microspore (figs. 11, 13), and that one of these cells corresponds in origin to the more usual evanescent cell. All gradations between an equal division and one which cuts off a lenticular evanescent cell have been found (figs. 6, 7, 10, 11, 13). In the double pollen grain of *Picea* one of the antheridial groups is homologous with the usual evanescent polar cell.

2. "*Prothallial cells*"

Several species have been described in which the "prothallial" cell has the power of division. Among the number are *Ginkgo biloba*, by STRASBURGER (1); *Picea excelsa*, by MIYAKE (2) and POLLOCK (3); *Abies balsamea* (9); *Agathis*, by JEFFREY and CHRYSLER (14); *Podocarpus*, by COKER (13a); and *Dacrydium* by Miss YOUNG (16). The similarity of the generative cell and the prothallial cells is pointed out by Miss YOUNG: "In *Dacrydium*, as in *Podocarpus* and *Abietineae*, a third cell is cut off from the main body of the spore. It overlies the others and is so similar to them that, but for its subsequent behavior, one might think it a prothallial cell. It is the generative cell, generative in the sense that it is the ancestor of the spermatogenous cell. This and the second prothallial cell now divide." The first prothallial cell may also divide. Again: "at shedding the pollen grain contains the body cell and five free nuclei. The nucleus of the body cell is indistinguishable from those of the prothallial cells and the tube nucleus." POLLOCK (3) states that in a large proportion of the gametophytes of *Picea excelsa* there is only one prothallial cell. BURLINGAME (20) says: "in *Podocarpus* one primary prothallial cell may be cut off, after which the free nucleus divides to form the free spermatogenous cell and the tube nucleus; or two primary cells may be cut off before the tube nucleus is separated from the primary spermatogenous cell." In these two species, as well as in *Picea canadensis*, the antheridial function is not limited to a definite primary derivative. It has been established that "prothallial cells" and generative cells may be similar in appearance; that frequently they are similar in their power of division; the similarity is further emphasized by the presence of "prothallial cells" in the pollen tube. The present account has emphasized the similarity in the origin, and has shown that potentially there is a similarity in function; that any one or sometimes two of the primary derivatives may be antheridial. To what extent we are justified in suggesting that these phenomena are indicative of a multi-antheridial ancestral form only further research can determine.

Relationships

No one character is sufficient to establish relationships of plant groups. Since similarity of male gametophytes gives only one-sided evidence for the relationship of species or genera, the discussion will be limited to comparison of types. In Taxodineae and Cupressineae the gametophyte consists of an antheridial cell, which may divide before or after shedding, and a tube nucleus; no evanescent cell is present. Similar gametophytes are found in *Picea canadensis* (fig. 30). In cycads two cells are cut off from the primary cell, one of which is antheridial (cf. fig. 38). The shedding stage characteristic of the abietinean gametophyte (also of *Ginkgo* and *Ephedra*) contains two more or less evanescent cells and an antheridial cell, which may or may not divide, beside the tube nucleus (cf. figs. 50, 51, 52). The podocarp type is similar, but the polar cells are not evanescent and frequently divide (cf. figs. 39, 40, 52). A massive polar tissue containing free nuclei, which LOPRIORE (18) regards as antheridial, is characteristic of the araucarian type. A similar gametophyte is shown in fig. 33. The male gametophyte of *Picea canadensis* is in a state of unstable equilibrium. Slight differences in conditions are sufficient to shift the balance in one of several possible directions. The resulting forms correspond to the various types of gametophytes found in gymnosperms.

Summary

In the male gametophyte of *Picea canadensis*, one, two, or three potentially antheridial cells are cut off from the primary cell; one of these divides to form a spermatogenous and a sterile cell; the others, when formed, are more or less evanescent. Occasionally there are two functioning antheridial cells, resulting in a bi-antheridial gametophyte.

The writer is indebted to Professor JOHN M. COULTER, Dr. CHARLES J. CHAMBERLAIN, and Dr. W. J. G. LAND for many suggestions and criticisms.

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EXPLANATION OF PLATES XV–XIX

The drawings (figs. 1–53) have been made with the aid of the Abbé camera lucida. The original magnification was 2000. A reduction of one-half has been made in reproduction.

FIGS. 1–13.—The first primary division; the primary cell retains its identity; the first primary wall cuts off an antheridial cell.

FIG. 1.—Primary cell.

FIG. 2.—A division at right angles to the longitudinal axis.

FIG. 3.—A division in the plane of the axis; a chromatic extrusion is being formed and is separating from the nuclear chromosomes.

FIGS. 4, 5.—Telophases: the primary nucleus and spindle fibers separating.

FIGS. 6, 7, 8, 11.—Telophases: each shows the cell plate in one of 4 positions; in fig. 8 both nuclei have escaped from the spindle fibers.

FIGS. 9, 12.—Two free nuclei in common cytoplasm; compare fig. 8.

FIGS. 10, 13.—The primary cell has given rise to two daughter cells, each of which may function as a sister primary cell.

FIGS. 14–27.—The second primary division.

FIG. 14.—The primary cell in contact with the first evanescent antheridial.

FIGS. 15, 16.—Prophases.

FIG. 17.—Anaphase: spindle fibers indistinct.

FIGS. 18–25.—Telophases: illustrate migration of primary nucleus and spindle fibers; fig. 24, a view from upper pole; figs. 23–25, the formation of the cell wall.

FIGS. 26, 27.—Pollen grains with primary cell and two non-functioning antheridial cells; compare size with fig. 1.

FIG. 28.—First antheridial ("prothallial") cell in division.

FIG. 29.—Primary cell; also first and second antheridial cells; the former has divided to form two nuclei.

FIG. 30.—First antheridial cell has divided to form a spermatogenous and sterile cell.

FIGS. 31, 32.—Two sister primary cells (cf. figs. 11 and 13) have given rise to a bi-antheridial gametophyte (disintegration).

FIG. 33.—Four free nuclei, products of first antheridial cell; the primary cell and second antheridial cell disintegrating.

FIGS. 34–36.—Chromatic extrusions.

FIG. 37—The position of the first primary wall and the large polar cavity is to be noted.

FIG. 38.—The second antheridial cell dividing.

FIGS. 39–40.—Laterally placed derivatives of first and second antheridial cells.

FIGS. 41–46.—The third primary division.

FIG. 41.—A polar view.

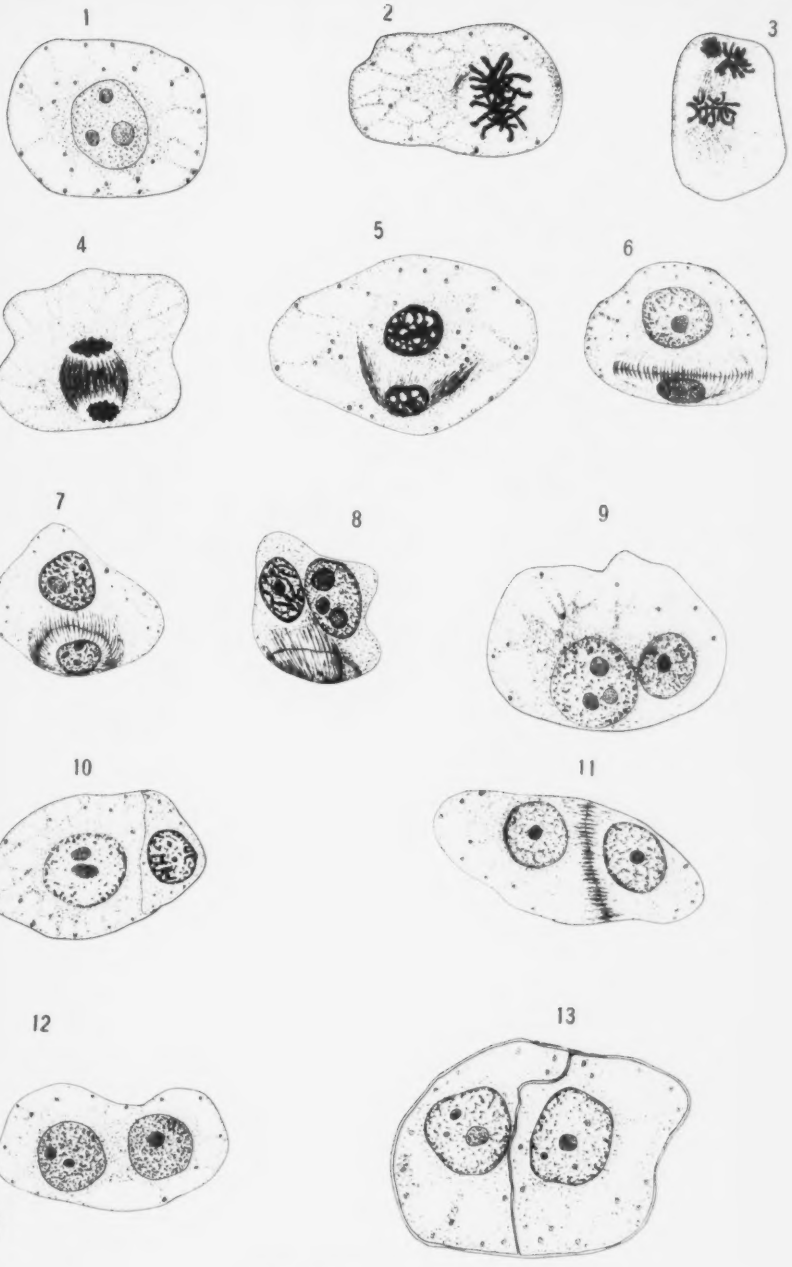
FIG. 46.—Large primary nucleus (tube nucleus): the third antheridial cell just before mitosis; the second in normal condition except for compression; the first disintegrated.

FIG. 49.—Mitosis in the first antheridial cell (cf. fig. 28).

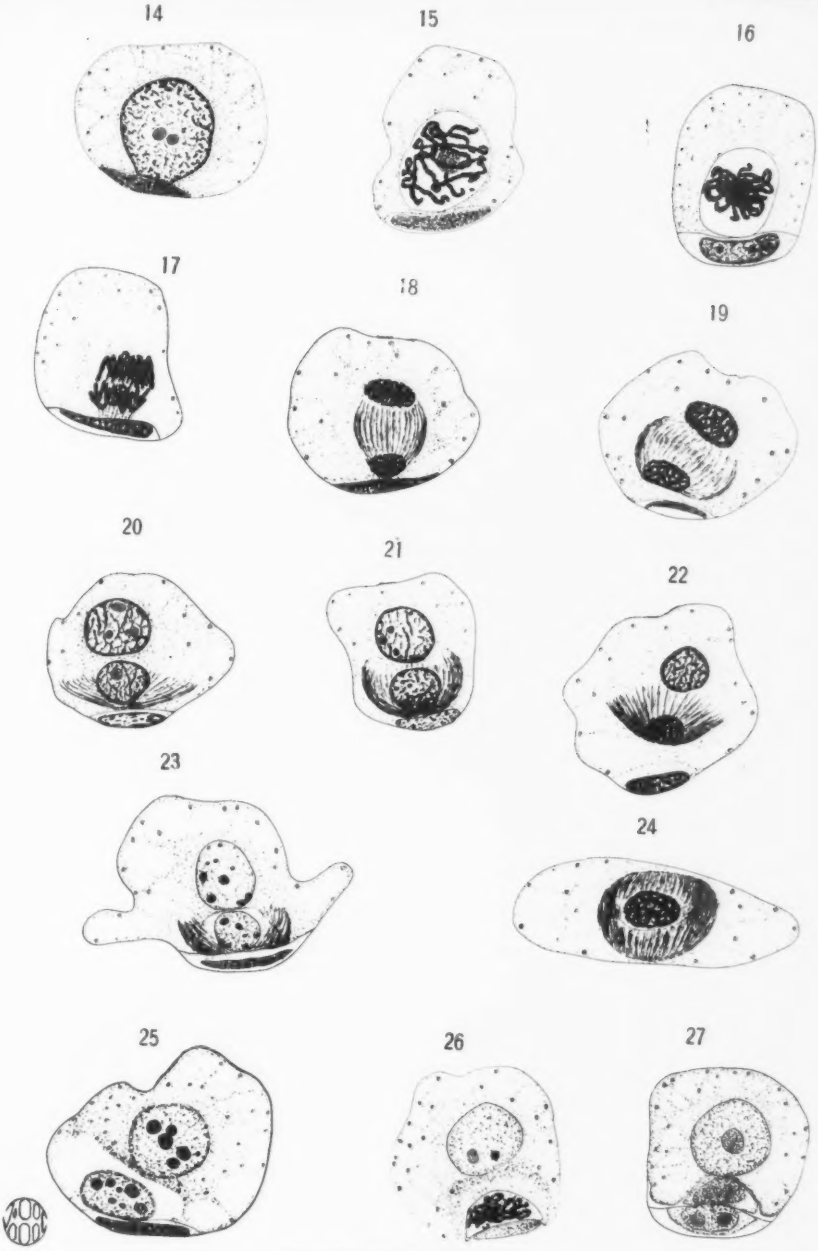
FIGS. 47, 48, 50, 51.—Division of the third antheridial cell to form a spermatogenous and a sterile cell.

FIG. 52.—Showing polar cells, the products of secondary divisions.

FIG. 53.—Shows disintegrating derivatives of the first antheridial cell; a sterile cell; a spermatogenous cell and the primary nucleus (or tube nucleus).



HUTCHINSON on PICEA



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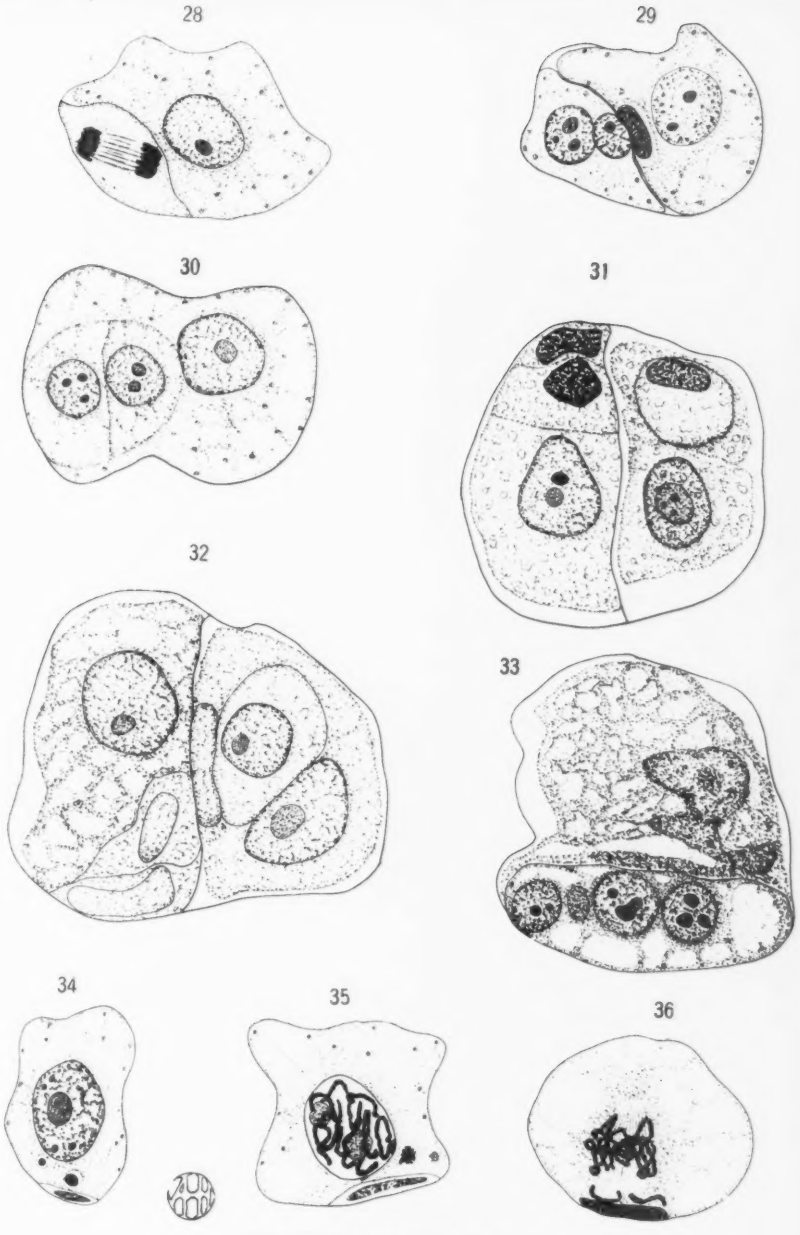

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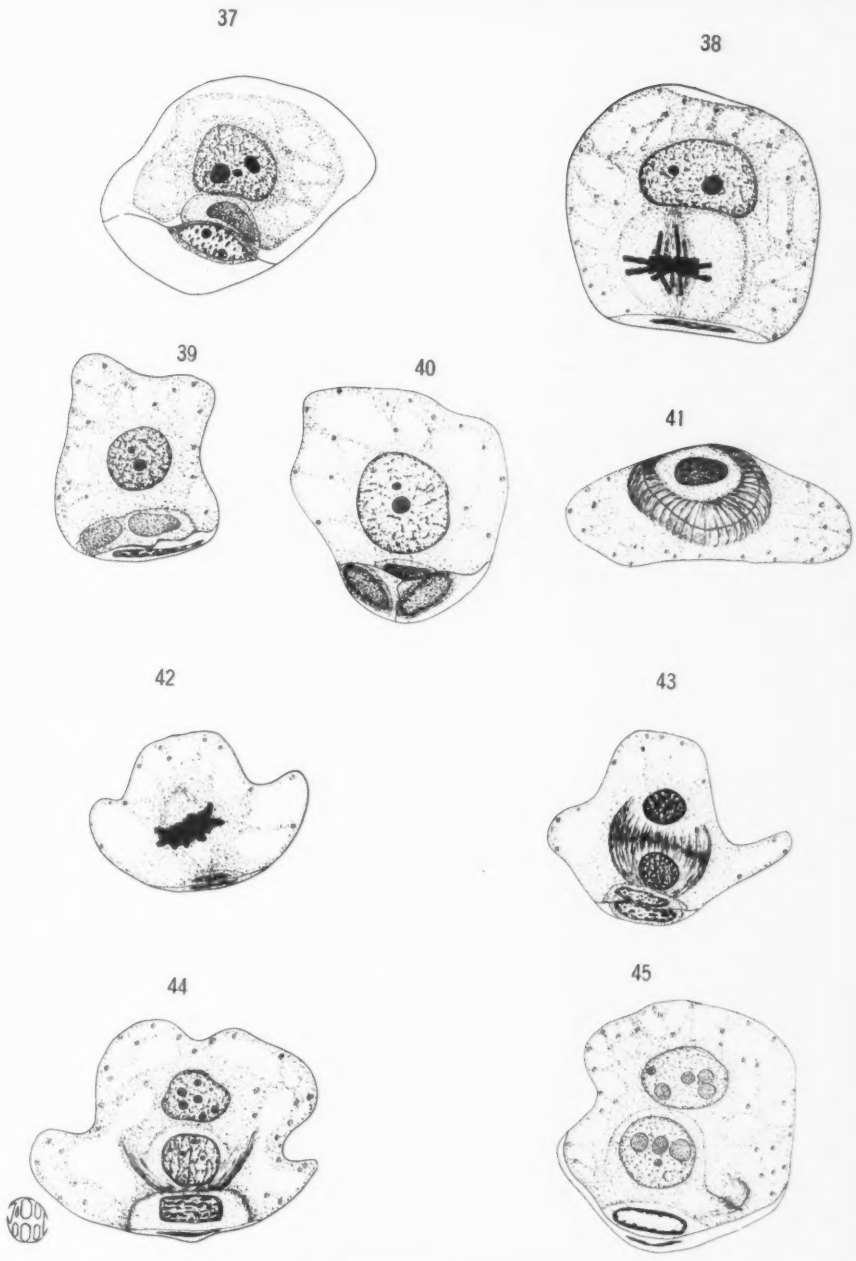

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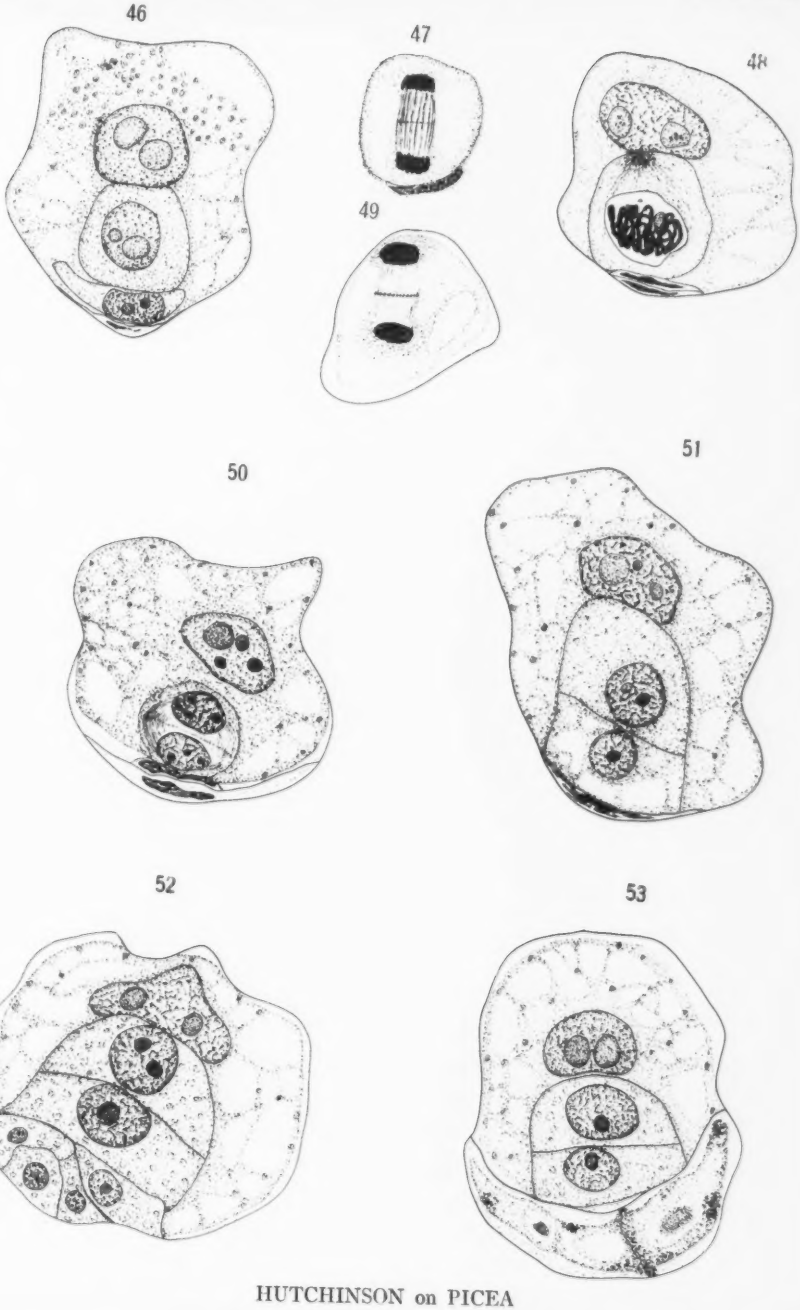

HUTCHINSON on PICEA

STUDIES IN THE GENUS BIDENS. II

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 201

EARL E. SHERFF

(WITH THREE FIGURES)

Bidens acuticaulis, sp. nov.—Herba annua, tenerrima, 4–8 dm. alta; caule acute angulato, ramoso; ramis adscendentibus, acute angulatis et fere subalata, remote pubescentibus. Folia opposita, petiolata, petiolo adjecto 1–4 cm. longa, pinnata aut irregulariter bipinnata; foliolis (et lobis) linearibus, 0.5–1 mm. latis. Petioli 2–10 mm. longi. Capitula multa, terminalia, 3–4 mm. alta et 2.5–3.5 mm. lata (frutescentia demum 1–1.2 cm. alta et 4–5 mm. lata), ligulata. Involucrum basi pubescens; squamis duplici serie dispositis; exterioribus linearibus, plus minusve pubescentibus, 3–4 mm. longis; interioribus lanceolatis, marginibus diaphanis 1.5–3 mm. longis. Ligulae circiter 4, parvae, sub-flavidae aut fere albae, 2–(4–) striatae, 3–5 mm. longae. Paleae lineare-lanceolatae, striatae, marginibus diaphanis. Achaenia linearia, remotissime pubescentia, margine adscendente-ciliato, apice erecto-hispido et biaristato aristis retrorsum hamosis, 6–12 mm. longa.

John Gossweiler 4052, in herb-grown woods, Angola, April 4, 1906 (type in Herb. Brit. Mus.).

Bidens rufovenosa, sp. nov.—Herba erecta, perennis (?), 4–6 dm. alta; caule subtereto, striato, glabro, plus minusve ramoso; ramis (aut ramulis) monocephalicis. Folia opposita, petiolata, petiolo adjecto 4–6 cm. longa, pinnata, spinuloso-ciliata, supra sparsim et brevissime spinuloso-pubescentia, infra sparsim pubescentia et ad venas minute rufo-tomentosa;[1] foliolis lateralibus lanceolatis (aut foliorum superorum lineare-lanceolatis), incisis aut longe dentatis; foliis supremis integris et lanceolatis, aut ternatis, foliolis integris et lanceolatis; petiolis basi connatis, foliorum

[1] Dr. S. ECKERSON, of the University of Chicago, has kindly made for me a critical examination of a leaf from the type, and she reports the color of the pubescence due to a red stain produced in the mucilage cells along the veins.

inferiorum angustis et 1–1.5 cm. longis, foliorum superorum brevioribus aut absentibus. Capitula ligulata, frutescentia 1–1.3 cm. lata et 0.8–1 cm. alta. Involucri squamae membranaceae, margine diaphanae, duplici serie dispositae; exterioribus (7–8) linearibus, 3–5 mm. longis; interioribus lanceolatis, dimidio longioribus. Ligulae (in specim. exsicc.) aurantiacae, anguste lanceolatae, apice integrae, ad basem minute hispidae, 7–9-lineatae, 1.5–1.8 cm. longae. Paleae membranaceae, lineares, margine diaphanae, 6–8 mm. longae. Achaenia linearia, subplana, una facie valde unicostata, adscendente-ciliatae, supra adscendente-hispidae, biaristatae aristis brevibus et nudis, 8–9 mm. longa.

John Gossweiler 4176, among the ferruginous rocks near the fort at Kabango, Princip. Amelia, Africa, Dec. 1907 (type in Herb. Brit. Mus.).

Bidens cinerea, sp. nov.—Herba, annua (?), erecta aut adscendente-erecta, cinerea; caule striato, squarroso-hispido, subtetragono, monocephalico (aut ramis monocephalicis). Folia opposita, petiolata, tuberculato-scabrida et minute spinuloso-setosa, ternata aut pinnata, petiolo adjecto 2–6 cm. longa; lobis dentatis aut lobulatis, ovatis aut lanceolatis, brevioribus paulo aut etiam dimidio quam petiolis; petiolis spinuloso-setosis, 0.5–2 cm. longis. Capitula terminalia, ligulata, pedunculis 6–10 cm. longis, flosculis hermaphroditis exsertis. Involucrum hispidum, squamis duplici serie dispositis; exterioribus circa 8, linearibus, 4–5 mm. longis; interioribus dimidio longioribus, lanceolatis, margine diaphanis. Ligulae flavae, lineari-lanceolatae, apici integro, 7–9-striatae, circa 1.2 cm. longae. Paleae lineares, membranaceae, margine diaphanae, circa 8 mm. longae. Achaenia linearia, nigra, compressa, uno facie unicostato, striata, adscendente-hispida, biaristata, aristis retrorsum hamosis, circa 1.1 cm. longa.

Lieut. *C. S. Smith*, May, 1893, Kilimanjaro, Africa (type in Herb. Kew).

Bidens punctata, sp. nov.—Herba annua, erecta, gracilis, ± 5 dm. alta, caule subtetragono, glabro (aut nodis sparsissime longo-piloso), striato, supra plus minusve sparsim ramoso; ramis subtetragonis aut teretis, tenuibus, striatis, glabris (nisi nodis pilosis); ramulis monocephalicis. Folia opposita, tripartita (infima et suprema integra), reflexa luce nigro-punctata demum, ciliata, supra sub-

glabra, infra pallidioria et sparse longo-hispida; lobis lateralibus brevibus, linearibus aut lanceolatis, integris (aut non saepe ad basim lobatis), basi saepe subangustatis; lobo terminali elongato, lineari aut lineari-lanceolato, integro (aut ad basim 1–2-dentato); petiolis plus minusve hispidis, basi connatis, 0.4–1 cm. longis. Capitula terminalia, longe (6–12 cm.) et tenuiter pedunculata, ligulata, capitula ligulata 2 cm. lata. Involucrum basi hispidum, squamis duplici serie dispositis; exterioribus (5–8) lineari-spathulatis, glabris aut hispido-ciliatis (aut etiam sparse hispidis), 2–4 mm. longis; interioribus lanceolatis, membranaceis, striatis, margine diaphanis, sparsim hispidis, 5–8 mm. longis. Ligulae flavae, lineari-lanceolatae, apice integro, 5–9-lineatae, 8–10 mm. longae. Paleae lineares, striatae, membranaceae, margine diaphanae, demum 6–7 mm. longae. Achaenia linearia, compressa, nigra, marginibus et faciebus tuberculatis aut tuberculato-hispidis, apici hispido pectinatim, biaristata, aristis 1–2 retrorsum hamosis.

Archdeacon *W. P. Johnson* 343, Tumbi (Makapula), April 27 (1901?; type in Herb. Kew); *idem* 341, Tumbi hill, Tumbi, April 27 (1901?).

The description here given is drawn mainly from the type sheet in Kew Herbarium, although certain dimensions, etc., are taken from *Johnson* 341 (also at Kew), a sheet with a larger and more matured plant. It may be remarked here that the punctate character noted above for the leaves is to be met with in *Bidens Taylori* and *B. Baumii* (see below), also a small number of other species.

Bidens vincaefolia Karsten et Schultz Bipontinus, sp. nov.—Herba, perennis (?), volubilis (?), caule angulato aut tetragono, ramoso; ramis glabris aut subglabris, tetragonis, striatis. Folia opposita, petiolata, petiolo adjecto 2–3 cm. longa, tripartita aut raro indivisa, subcoriacea aut membranacea, subtus pallidiora et ad venas minute pubescentia, marginibus integris ("rarius serrata" ex Karst. et Schz. Bip.) et in specimine sicco subrevolutis; foliolo terminale lanceolato, 1–1.8 cm. longo; foliolis lateralibus oblanceolatis aut obovatis, 0.6–1.3 cm. longis; petiolo ciliato, 1–1.8 cm. long. Capitula pedunculata, ligulata, circiter 1 cm. lata. Involucrum basi hispidum; squamis duplici serie dispositis et subaequalibus; exterioribus circiter 5, linearibus, plus minusve pubescentibus, nigro-striatis, 3–4 mm. longis; interioribus

lanceolatis, subglabris. Ligulae circiter 6 aut 7, flavae, nigro-striatae nonnullis lineis, 5–8 mm. longae. Paleae lineares, striatae, marginibus diaphanis. Achaenia linearia, biaristata aristis retrorsum hamosis, circiter 1 cm. longa.

Karsten, Bogota, Columbia (type in Herb. Mus. Hist. Nat. Paris).

This species appears very unique, being distinct in general aspect from any other species known to me. The type sheet, originally in SCHULTZ BIPONTINUS' own herbarium, bears several small specimens. These are remarkably uniform and are allied most nearly with *Bidens rubifolia* H. B. K., the leaves of which are much less diminutive. The label bearing the specific name here set forth has also the date Dec. 18, 1856, which, from its position on the label, may be that of the determination rather than the collection. While true *Bidens rubifolia* grows at Bogota (e.g., *I. F. Holton* 365, Oct. 28, 1852), KARSTEN and SCHULTZ BIPONTINUS evidently regarded the Karsten plant specifically distinct. This course I also must adopt, as I am unable to connect the two forms in herbaria by any intermediate forms.

BIDENS ODORATA Cav. Icon. et Descript. Plant **1**:9. *pl. 13.* 1791; *Coreopsis ferulaefolia* Jacq. var. *odoratissima* Pers. Synops. Plant. **2**:477. 1807; *Bidens ferulaefolia* DC. var. *odoratissima* DC. Prodr. **5**:603. 1836.—For many years, PERSOON's variety *odoratissima* of *Coreopsis ferulaefolia* seems to have been unfamiliar to botanists. DECANDOLLE (*l. c.*) merely mentioned it: "quid sit var. *odoratissima* à Persoonio citata ignoro." PERSOON's variety was founded on CAVANILLES' plant in JUSSIEU's herbarium and was said to be native to Peru. This cited specimen I have not found, but there exists in the British Museum a good specimen from CAVANILLES, labeled "*Coreop*[*s*]*is odoratissima* nobis, Mexico," which matches PERSOON's description precisely. The leaves, probably because of having grown under cultivation, are especially slender-divided and give a superficial resemblance to those of *Bidens ferulaefolia* (Jacq.) DC. The specimen is identical with two other specimens (in Herb. Brit. Mus.) from the herbarium of CAVANILLES, one labeled "*Coreopsis odorata* olim *Bidens*," and the other "*Bidens odorata* Cav. Ic. V. 1, nunc *Coreopsis*." Both of these last two are further labeled, in pencil, "*Cosmos odoratus*."

A study of other mature specimens of *Bidens odorata* shows that it is a Mexican species primarily (if not indeed exclusively), and is not at all a *Coreopsis*, but rather a true *Bidens*, although

having achenes sometimes approaching those of *Cosmos* and with rays varying, in herbarium specimens, from yellow to white, rose, or violet (a single sheet frequently showing all these variations, as, for example, *Palmer* 674, Herb. Kew).

During the past few years, certain writers, notably OLIVER and HIERN, S. L. MOORE, and O. HOFFMANN, have described a considerable number of striking and positively new species of *Coreopsis* and *Bidens* from various parts of Africa. In their generic distinctions, however, they have unfortunately been guided mainly by the direction of the barbs on the awns of the achenes, or, in certain cases, they have had access at the time to immature achenes only. Regarding the latter point, the disadvantage and source of error are at once evident on examining the real distinctions between *Coreopsis* and *Bidens*. As will be seen below, the presence of two more or less conspicuous lateral wings upon the achenes seems by far the most nearly constant character of *Coreopsis* as distinguished from *Bidens*. But in several species of *Coreopsis* these wings are completely lacking on the immature achenes. Thus, species described from immature specimens as *Bidens* may later prove to be *Coreopsis*. Again, a species erroneously described from immature specimens as *Coreopsis*, because of a recognized resemblance to some particular species of *Coreopsis* and disregarding the absence of wings, must thereafter be treated by botanists as *Coreopsis* until mature material can be obtained to prove its status as true *Bidens*.

Concerning the direction of the barbs on the awns of the achenes, however, a more detailed statement is needed. Until comparatively recent times, botanists referred to *Bidens* those species with retrorsely barbed awns, and to *Coreopsis* those species with antrorsely barbed awns or with awns inconspicuous. But, from time to time in North America, new forms have been discovered, identical in each case with a certain species of *Coreopsis* (as then delimited) or *Bidens* except in the direction of the barbs on the awns. ASA GRAY (cf. FERNALD, Rhodora **15**:77. 1913), when confronted with such a form of "*Coreopsis aristosa* Michx." (the then accepted name), designated it "*C. aristosa* in Bidentem transformata." Later (Synop. Fl. N. Amer. **1**^{II}:294–296. 1884) he treated this

and similar forms as hybrids between *Coreopsis* and *Bidens*. Still later, BRITTON (Bull. Torr. Bot. Club **20**: 280–281. 1893), emphasizing the instability of the barb-direction character for *Bidens frondosa* L., and also separating the two genera on general grounds rather than by one particular character, transferred six species from *Coreopsis* to *Bidens*. The validity of these transfers has since been accepted unhesitatingly by all prominent American botanists who have critically studied the Eastern United States species of *Bidens*, among them WIEGAND (Bull. Torr. Bot. Club **26**: 401. 1899), GREENE (e.g., Leafl. Bot. Crit. **1**: 200.[2] 1906), and ROBINSON and FERNALD (GRAY'S Man. ed. 7. p. 839. 1908). It is also implied by many other American botanists working upon the species of other regions but following the same distinctions, a singular case being that of BRANDEGEE'S description (Zoe **5**: 239. 1908) of *Bidens alpina* and GREENMAN'S description (Proc. Amer. Acad. **41**: 264. 1905) of *Bidens sarmentosa*. The achenes are described for *B. alpina* as "nearly smooth; awns none or two varying from 1 mm. long to rudiments, corneous and not barbellate"; for *B. sarmentosa*, as "glabrous or sparingly hispidulous, awnless or with reduced awns." But, on investigation, these species are found to be identical; in turn, *B. sarmentosa*, which from priority of publication would otherwise stand as the accepted species, is found to match[3] in every character *Coreopsis anthemoides* DC., having achenes described (DC. Prodr. **5**: 573. 1836) as "(immaturis) linearibus glabris brevissime bidentatis." Thus, a species placed by DECANDOLLE in *Coreopsis*, evidently because of its very short awns, was independently referred by BRANDEGEE and by GREENMAN, about 70 years later, to *Bidens*, evidently

[2] Thus, GREENE refers to *Bidens* a plant ("*B. tenuissima*") with "erect, *upwardly barbed awns*."

[3] I have examined several authentic cotypes of *B. alpina*, the type and numerous authentic cotypes of *B. sarmentosa*, also several cotypes of "*Coreopsis anthemoides*" (*Bidens anthemoides* Sherff, BOT. GAZ. **56**: 493. 1913). War conditions in Europe have precluded for the present my examination of DECANDOLLE'S type at Geneva. However, the characters cited by DECANDOLLE and his comparison of this species with *Anthemis arvensis*, which it at times simulates in habit to a remarkable degree, leave no doubt that the cotypes examined (in Herb. Brit. Mus. and elsewhere) truthfully represent the type.

because the achenes lack wings and the general characters coincide closely with those of certain unquestioned species of *Bidens* (e.g., *B. humilis* H. B. K., with awns retrorsely barbed).

FERNALD, in a recent discussion of the awn characters of *Bidens* (Rhodora **15**: 74–78. 1913), lists no less than six American species in which occurs a more or less pronounced form having the awns barbed in the reverse from the normal direction. Thus, for example, *Bidens connata* Muhl. has awns retrorsely barbed, while var. *anomala* Farwell has awns antrorsely barbed. Again, *Bidens aristosa* (Michx.) Britton has antrorsely barbed awns, while the probably valid var. *Fritcheyi* Fernald has retrorsely barbed awns. Hence it is obvious that, were the old artificial method of distinguishing between *Coreopsis* and *Bidens* (namely by the direction of the barbs on the awns) to be retained, an anomalous situation would result. We should be compelled either to regard each of these varieties as a hybrid between two species of distinct genera, a course certainly unwarranted in several cases (cf. FERNALD, *l. c.*, and WIEGAND, Bull. Torr. Bot. Club **26**: 401. 1899), or to refer each variety to the other genus, an entirely indefensible alternative. We are compelled, then, to view these varieties, in at least the majority of cases, as merely more or less distinct and pronounced forms of their respective species. This being true, the awn character method of separating *Coreopsis* from *Bidens* proves utterly worthless, and must be permanently abandoned, as it indeed has been by American botanists.

On reference to recent descriptions and types of African species of *Bidens*, we find that in several cases the awns, even on achenes on the same head, are barbed both antrorsely and retrorsely. Thus, for example, MOORE (Jour. Linn. Soc. Bot. **37**: 322. 1906) created the name *Bidens ambigua* for *Gossweiler* 1189, precisely for the reason that some of the awns are smooth, others antrorsely barbed, and others retrorsely barbed ("achaeniis . . . . aristis 2 quam se ipsa brevioribus dentibus perpaucis nunc erectis nunc recurvis onustis vel etiam omnino calvis . . . . , hence the trivial name"). Yet in the same year (Jour. Bot. **44**: 22. 1906) he likewise somewhat arbitrarily created the name *Coreopsis Taylori* for a plant showing the same variation (coll. *W. E. Taylor*, Jan. 5, 1886;

"achaeniis . . . apice setuloso-ciliatis calvis vel aristulis 1 vel 2 brevissimis erecto—vel patenti—vel etiam recurvo—uncinulatis onustis saepe vero nudis . . . ; indeed, the plant might almost as well be considered a *Bidens*, but the habit is that of *Coreopsis*"). In referring the latter species to *Coreopsis*, he relied mainly upon its habital similarity to other (so-called) species of *Coreopsis* from Africa. But, as will be seen presently, some of these species belong in reality to *Bidens*. Therefore, this habital similarity, affording formerly an apparently good reason for the name *Coreopsis Taylori*, can no longer be given much consideration.

The present writer, in bringing together the numerous species of *Bidens* for monographic treatment, has come to adopt fully the generic limits of these two genera as followed by recent American botanists. In brief, the genus *Coreopsis* is maintained primarily because of the peculiar habit and winged achenes of the Linnaean type species (excluding *C. alba*, *C. Bidens*, and *C. alternifolia*, Sp. Plant ed. 1. pp. 907–909. 1753; cf. BRITTON, Bull. Torr. Bot. Club 20: 280. 1893). Similarly, the genus *Bidens* is maintained primarily because of the peculiar habit, strongly barbed awns, and wingless achenes of several of the Linnaean type species of *Bidens*. Among the species of either small group a fair degree of uniformity in several characters occurs. But on extending our observations to other species of *Coreopsis* and *Bidens*, we find remaining no absolute uniformity in even one distinctive character. However, one such character does persist to a surprising extent. It is the presence (in *Coreopsis*) or absence (in *Bidens*) of two lateral wings upon the mature achene. Among so many species from widely remote regions does this character separate two genera with different aspects that, *in cases where other criteria are absent*, it appears to offer the only logical basis of distinction. Accordingly, and with a view to thus delimiting these two genera more accurately, notably among the African species (where the generic limits tend to overlap) this basis of distinction is here adopted. As a consequence, it is found necessary to make the following transfers for the flora of Africa. This list includes only those species upon the types or other positively authentic material of which I have personally examined the mature achenes.

Bidens arenicola (S. Moore), comb. nov.—*Coreopsis arenicola* S. Moore, Jour. Linn. Soc. **37**:170. 1905.

Bidens Grantii (Oliver), comb. nov.—*Coreopsis Grantii* Oliver, Trans. Linn. Soc. **29**:98. *pl. 65*. 1873.

Bidens grandis, nom. nov.—*Coreopsis speciosa* Hiern, Cat. Welw. Afr. Pl. **3**:585. 1898.

Bidens Kirkii (Oliver and Hiern), comb. nov.—*Coreopsis Kirkii* Oliver and Hiern, Fl. Afr. Trop. **3**:390. 1877.

The type material (in Herb. Kew) lacks mature achenes, but the mature material of *G. F. Scott Elliot* 6909, referable to this species, has the achenes of a true *Bidens*.

Bidens ambacensis (Hiern), comb. nov.—*Coreopsis ambacensis* Hiern, Cat. Welw. Afr. Pl. **3**:586. 1898.

Bidens ugandensis (S. Moore), comb. nov.—*Coreopsis ugandensis* S. Moore, Jour. Linn. Soc. **35**:347. 1902.

Bidens ruwenzoriensis (S. Moore), comb. nov.—*Coreopsis ruwenzoriensis* S. Moore, Jour. Linn. Soc. **35**:345. 1902.

Bidens kilimandscharica (O. Hoffm.), comb. nov.—*Coreopsis kilmandscharica* O. Hoffm., Bot. Jahrb. **20**:234. 1894.

Bidens Schweinfurthii, nom. nov.—*Coreopsis linearifolia* Oliver and Hiern, Fl. Afr. Trop. **3**:390. 1877.

This species is here given a new name to avoid any possible confusion with *Bidens linearifolia* Schz. Bip., which, in fact, is a true *Cosmos* and has been renamed correctly *C. linearifolius* Hemsley (Biol. Centr. Amer. 2:200. 1881).

Bidens Taylori (S. Moore), comb. nov.—*Coreopsis Taylori* S. Moore, Jour. Bot. **44**:22. 1906.

Bidens insecta (S. Moore), comb. nov.—*Coreopsis insecta* S. Moore, Jour. Bot. **46**:42. 1908.

Bidens Baumii (O. Hoffm.), comb. nov.—*Coreopsis Baumii* O. Hoffm. in H. Baum Kun.-Sambes. Exped. 419. 1903.

Bidens Elliotii (S. Moore), comb. nov.—*Coreopsis Elliotii* S. Moore, Jour. Linn. Soc. **35**:346. 1902.

BIDENS FLORIBUNDA H. B. K., Nov. Gen. **4**:238. 1820; *Bidens simplicifolia* Wright, Kew Bull. 1906: 5. 1906.—The type of *B. simiplicifolia* Wright (in Herb. Kew) is identical with the type

specimen of *B. floribunda* H. B. K. (in Herb. Mus. Hist. Nat. Paris).[4] An important feature of *B. floribunda* is its simple leaves, although KUNTH, in the original description, betrayed doubt as to whether tripartite leaves are completely lacking (foliis . . . simplicibus, nisi folia inferiora, a me haud visa, in hac quoque specie ternata sint"). WRIGHT, in describing *B. simplicifolia* ("a speciebus reliquis Austro-Americanis foliis indivisis ovatis acuminatis differt"), was clearly unaware that this same species had already long before been described from the same country (Ecuador) as *B. floribunda*. An excellent cotype of *B. simplicifolia* in the Herbarium of Field Museum has foliage much superior to that of the type. It possesses four pairs of large simple leaves, the lowermost ones 15.2 cm. long and 5.6 cm. wide. From these it would appear even more plausible that the species is constantly simple leaved.

BIDENS ALAUSENSIS H. B. K., Nov. Gen. 4:184. 1820; *Bidens valparadisiaca* Colla, Mem. Accad. Torin. **38**:12. *pl. 24.* 1835; *Bidens chilensis* DC., Prodr. **5**:603. 1836.—A study of several authentic specimens of *B. chilensis* DC. collected around Quillota, Chile, by BERTERO about 1829, shows that these are precisely the same as the type specimen (fig. 1) and BONPLAND'S private duplicate specimen of *B. alausensis* H. B. K. (both specimens in Herb. Mus. Hist. Nat. Paris). Other specimens, collected at various dates by GAY, W. H. HARVEY, BRIDGES, etc., and all determined as *B. chilensis*, show that the rays are frequently white, as stated by BERTERO (DC., *l. c.*), instead of yellow, as in DECANDOLLE'S type specimen.

Regarding *B. valparadisiaca* Colla we need only to say that it was founded upon BERTERO'S material, as was DECANDOLLES *B.*

[4] The only difference that I can detect is that, in at least its cotype material examined, *B. simplicifolia* has the exterior involucral bracts mainly subspatulate and only slightly ciliate; in the type of *B. floribunda*, these are more oblong and more ciliate. While such a variation in shape or size of these bracts has already, in some species, been made the basis for a varietal distinction (e.g., *B. rosea aequisquama* Fernald, Proc. Amer. Acad. **43**:68. 1907), such a course would seem undesirable here. Aside from the fact that these bract characters frequently vary, in other better known species of *Bidens*, from oblong to spatulate on the same head, it would mean the unwelcome use, according to rules, of the name *simplicifolia* for a variety of a species that itself is simple leaved (*simplicifolia*).

chilensis,[5] and hence likewise must be synonomized with *B. alausensis*.

It is interesting to note that *Bidens crithmifolia* H. B. K. was suspected by SPRENGEL (Syst. Veg. ed. 16[III]. p. 454. 1826) of belonging to *B. alausensis*. A study of the types of both species shows, however, that they are entirely distinct.

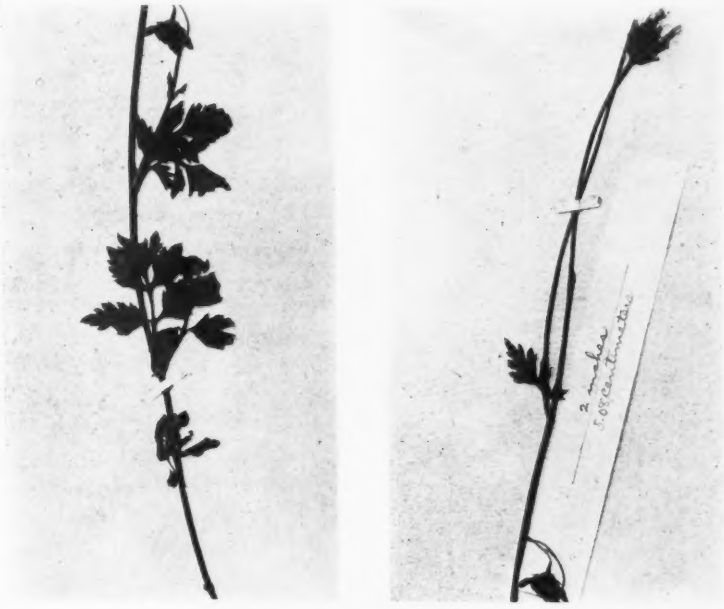

FIG. 1.—Type of *Bidens alausensis* H. B. K. in Herb. Mus. Hist. Nat. Paris; the two photographs slightly overlap.

BIDENS TENELLA L., Amoen. Acad. **6**:96. 1763.—This species, was included by DECANDOLLE (Prodr. **5**:605. 1836) among the "species non satis notae." A sheet with two specimens exists however, in the Linnaean Herbarium. These are in good condition and show at once that the species is in no way a *Bidens*, and

[5] *B. valparadisiaca* was based (COLLA, *l. c.*) upon a specimen from Valparaiso, while *B. chilensis*, which DECANDOLLE himself equated with it, was based upon a specimen collected in the immediate vicinity, but to the northeast ("circa Quillota," DC., *l. c.*).

may even be founded upon two distinct plants from widely separate parts of the world. In fact, the sheet bears a determination by SCHULTZ BIPONTINUS, naming the plant "ad sinistram *Pectis* (*tenella*)" and that "ad dextram Charieis *heterophylla* Cass."

BIDENS ANDONGENSIS Hiern, Cat. Welw. Afr. Pl. 1[III]:588. 1898.—At the time of describing this species, HIERN confessed himself uncertain as to its generic status, owing to the insufficient material. Since then, however, an admirable, well developed specimen (*John Gossweiler* 3631, Angola, August 3, 1907) has been received at the Herbarium of the British Museum. This matches sufficiently in each detail the plant fragment and drawings on the type sheet, at the same herbarium, and proves conclusively that the species is a true *Bidens*.

Bidens elata, comb. nov.—*Bidens cernua* L. var. *elata* Torr. and Gr., Fl. N. Amer. 2:352. 1842; *Bidens dentata* Wieg., Bull. Torr. Bot. Club 26:412. 1899, non *Bidens quadriaristata* DC. var. *dentata* Nutt.; *Bidens amplissima* E. L. Greene, Pittonia 4:268. 1901. —An excellent specimen of this species, collected by SCOULER at the Straits of De Fuca, is in the Torrey Herbarium, now included in the Herbarium of the N.Y. Bot. Garden. It is identical with the Scouler specimen of HOOKER'S herbarium (now in Kew Herb.), a specimen referred by HOOKER (Hook. Fl. Bor. Amer. 1:314. 1833) to *B. chrysanthemoides* Michx. (but entirely distinct from Michaux's two type specimens in Herb. Mus. Hist. Nat. Paris). It is identical also with the type and cotype specimens of *B. amplissima* Greene. However, it is very different from the type (fig. 2) of *B. quadriaristata* DC. var. *dentata* Nutt. (in Herb. Brit. Mus.), a plant cited synonomously by TORREY and GRAY, but probably never seen by them, as indeed their failure to use their customary exclamation marks would partly imply.

WIEGAND, following TORREY and GRAY'S treatment, likewise equated these two plants, but GREENE (*l. c.*), who, however, had not seen NUTTALL'S type, justly denied their identity. Still GREENE'S name *B. amplissima* is superfluous according to rule of nomenclature, and the name *elata*, supported by a description ("leaves . . . . unequally and incisely serrate," etc., Torr. and

Gr., *l. c.*) that very definitely characterizes the cited specimens,[6] must be used for this species.

Bidens aurea, comb. nov.—*Coreopsis aurea* Ait., Hort. Kew. 3: 252. 1789; *Bidens coronata* auct., non L.—In a former article

FIG. 2.—Type of *Bidens quadriaristata* DC. var. *dentata* Nutt., in Herb. Brit. Mus.

(BOT. GAZ. **56**:495. 1913), it was stated that BRITTON and not FISCHER was the one to transfer *Coreopsis coronata* L. to *Bidens*. An inspection, furthermore, of BRITTON's article cited (Bull. Torr.

[6] At least the Scouler specimens. I have not seen the Douglas specimens.

Bot. Club **20**:280. 1893) shows that he was merely treating a group of *Coreopsis* species of GRAY'S *Synoptical flora* en masse, and was concerned with their generic rather than specific status. And study of GRAY'S descriptions and notes (GRAY, Synop. Fl. N. Amer. 1^{II}:294. 1884) shows that GRAY equated, though somewhat provisionally, *Coreopsis aurea* Ait. with *C. coronata* of the Linnean Herbarium, a view retained as well by BRITTON (BRITTON and BROWN, Illustr. Fl. **3**:498. 1913).

My search through the material of *Bidens* and nearly allied genera at Kew Herbarium failed to reveal an original specimen of *Coreopsis aurea* Ait., but a good and authentic sheet from Kew Gardens, in 1785, occurs in the Herbarium of the British Museum. It is the form recently treated by authors as *Bidens coronata* (e.g., BRITTON and BROWN, *l. c.*). In the Linnaean Herbarium, moreover, there still exists the original superb specimen of *Coreopsis coronata* L. It lacks mature achenes, but its several beautiful 8-rayed heads, with the rays strikingly well arranged on the paper (fig. 3), leave no doubt that LINNAEUS had this specimen at hand when describing *C. coronata* (Sp. Plant. ed. 2. **2**:1281. 1763; "radio magno, octopetalo," etc.). While, indeed, LINNAEUS cited in his synonomy plants of VAILLANT and of PLUMMIER, these have been justly excluded by subsequent authors. Thus, for forming a true conception of *C. coronata* L., there are left for us the Linnaean specimen and description. The latter, by itself, is inadequate. The former, in GRAY'S time, seemed likewise disappointing, as being too nearly intermediate between *C. aurea* Ait. and *C. trichosperma* Michx. of his *Synoptical flora*. But, in later years, numerous specimens of these last two species have been added to our American herbaria and show very clearly differences in leaf outlines that GRAY, with his scantier material, could not properly define. A comparison with these specimens shows at once that the Linnaean type is the *Coreopsis trichosperma* Gray (*l. c.*), and hence *Bidens trichosperma* Britton.[7]

[7] Since the foregoing lines were written, Dr. N. L. BRITTON has kindly written me that many years ago he examined the Linnaean type, but, while entertaining doubts as to its true status, felt constrained, for want of achenes, to follow GRAY'S treatment, except as to generic affiliations. However, Dr. M. L. FERNALD has just informed me that GRAY'S fragment at Gray Herbarium, from the Linnaean Herbarium (where certain heads are missing on the single type specimen), "shows perfectly characteristic fruit of *B. trichosperma*, not of *B. coronata* of recent authors," thus confirming my conclusions in a most emphatic way.

My inability to find MICHAUX's specimen of his *Coreopsis trichosperma* in the Michaux collection at Paris (in Herb. Mus. Nat.

FIG. 3.—Type of *Bidens coronata* (L.) Britton in Herb. Linn.

Hist. Paris) makes it impossible to state definitely whether MICHAUX's specimen was *Bidens aurea* (Ait.), as here introduced, or

B. coronata (L.) Britton. Fortunately, lack of priority in either case precludes the use of MICHAUX's name *trichosperma*, and we thus are able to use names—*B. aurea* (Ait.) and *B. coronata* (L.) Britton—that are supported with authentic type or cotype specimens still extant and in a good state of preservation.

The plant with leaves divided into linear segments (*Diodonta leptophylla* Nutt., Trans. Amer. Phil. Soc. II. **7**:360. 1841; *Bidens coronata* var. *leptophylla* Mohr, Contrib. U.S. Nat. Herb. **6**:808. 1901) must properly be designated *Bidens aurea* (Ait.), var. **leptophylla** (Nutt.), comb. nov. NUTTALL's original specimen is still preserved in excellent condition (in Herb. Brit. Mus.).

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ON THE DECREASE OF PERMEABILITY DUE TO CERTAIN BIVALENT KATIONS

W. J. V. OSTERHOUT

(WITH ELEVEN FIGURES)

It has been shown[1] that while NaCl and many other salts of monovalent metals increase the permeability of protoplasm, $CaCl_2$ has the opposite effect. This effect of $CaCl_2$ is not permanent; if the exposure be sufficiently prolonged, it will be found that it gradually passes away and is followed by an increase of permeability. The question arises, do other bivalent kations behave like calcium?

The method employed in this investigation was to make determinations of the electrical resistance of living tissues of *Laminaria saccharina* in the manner described in a previous paper.[1] Such determinations afford an accurate measure of the permeability of the protoplasm.

The following experiment[2] will illustrate the effects of $CaCl_2$. The resistance of a cylinder of tissue in sea water at 18°C. was found to be 1000 ohms. It was transferred to $CaCl_2$, 0.278M, which had the same conductivity as the sea water. After 15 minutes the resistance in $CaCl_2$ at 18° was found to be 1490 ohms. After 30 minutes more the resistance was still 1490 ohms. Another reading taken 105 minutes later showed the resistance to be 950 ohms; 75 minutes later it was 650 ohms. During this time the control in sea water had not altered its resistance. The results are shown in table I and fig. 1.

The resistance at the beginning of the experiment was 1000 ohms; subtracting from this the resistance of the apparatus (250 ohms) gives the net resistance or the actual resistance of the tissue, which is $1000-250=750$ ohms. The net conductance was $1\div750$

[1] Science N.S. **35**:112. 1912.

[2] The chemicals used were the best obtainable and in nearly all cases were Kahlbaum's. The solutions unless otherwise stated were neutral to litmus. This is important, for it has been shown in a previous paper acid may cause a rise in resistance.

$=0.00133$ mho. After 15 minutes in $CaCl_2$ the net resistance was $1490-250=1240$ ohms, and the net conductance $1\div1240=0.00081$ mho. We may regard the permeability as equal to the conductivity, or, in this case, for convenience, as equal to the conductance. The decrease in permeability was therefore $0.00133-0.00081=0.00052$ mho or 39.1 per cent.

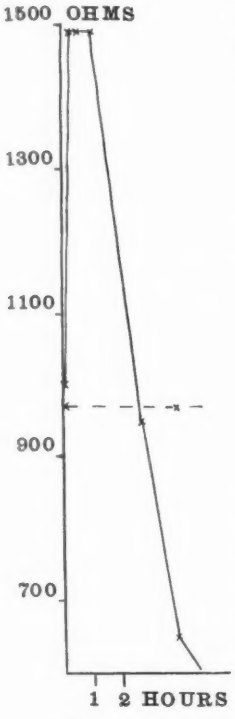

FIG. 1.—Curve of electrical resistance of *Laminaria saccharina* in $CaCl_2$ 0.278 M (unbroken line) and of a control in sea water (dotted line).

TABLE I

ELECTRICAL RESISTANCE OF *Laminaria saccharina*

Time in hours	In $CaCl_2$ 0.278 M	In sea water
0	1000	970
$\frac{1}{4}$	1490	970
$\frac{1}{2}$	1490	970
1	1490	970
$2\frac{3}{4}$	950	970
4	650	970

All readings were taken at 15° C.

The characteristic effects of $CaCl_2$ are therefore a very rapid rise followed after an interval by a fairly rapid fall of resistance. It seems probable that these effects result from two processes which go on simultaneously and represent different reactions, one of which has a much greater velocity than the other. In this way the period of stationary resistance (represented by the flattened top of the curve) would be accounted for. The fall in resistance is much slower than that caused by monovalent kations and is, in the opinion of the writer, quite different from it.

Similar results were obtained with $BaCl_2$ and $SrCl_2$.

The behavior of material in a solution of $MgCl_2$, about 0.28 M, having the same conductivity as sea water, is shown in table II and fig. 2. The rise in resistance is not nearly as great as in $CaCl_2$; the fall in resistance begins much sooner and proceeds much more rapidly. The top of the curve is not flattened.

The writer interprets this to mean that the velocity of the second reaction (causing the fall in resistance) is approximately equal to that of the first reaction (causing a rise in resistance).

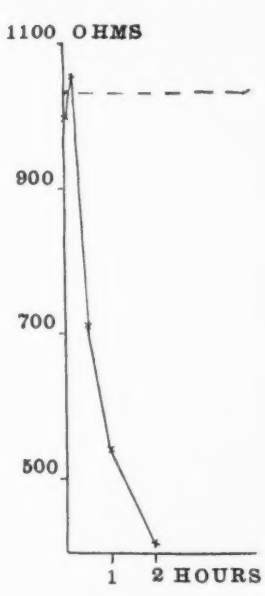

FIG. 2

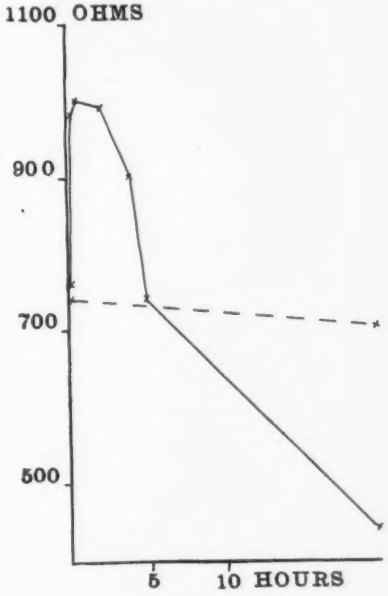

FIG. 3

FIGS. 2, 3.—Fig. 2, curve of electrical resistance of *Laminaria saccharina* in $MgCl_2$ 0.28 M (unbroken line) and of a control in sea water (dotted line); fig. 3, curve of electrical resistance of *Laminaria saccharina* in $MnCl_2$ 0.317 M (unbroken line) and of a control in sea water (dotted line).

TABLE II

ELECTRICAL RESISTANCE OF *Laminaria saccharina*; AVERAGE OF THREE EXPERIMENTS

Time in minutes	In $MgCl_2$ 0.28 M	In sea water
0	1000	1030
10	1055	....
30	710	....
60	545	....
120	410	1030

All readings were taken at 18° C.

In a solution of $MnCl_2$ (about 0.317 M), having the same conductivity as sea water, the tissue shows a rapid and very decided rise, followed by a fall which is noticeably slower than that in $CaCl_2$. The results, as shown in table III and fig. 3, are in marked contrast to those obtained with $MgCl_2$.

TABLE III

ELECTRICAL RESISTANCE OF *Laminaria saccharina*

Time in hours	In $MnCl_2$ 0.317 M	In sea water
0	760	740
$\frac{1}{4}$	980	...
$\frac{1}{2}$	1000	...
2	990	...
4	900	...
5	740	...
20	440	700

All readings were taken at 18° C.

The rise in resistance in these solutions was so great that it seemed to the writer that a rise might be obtained when the substances in question were added directly to the sea water, either as concentrated solutions or in solid form. Accordingly 10 cc. of $CaCl_2$ 5 M were added to 1000 cc. of sea water and a lot of tissue was placed in it. The resistance rose[3] from 1290 to 1390 ohms, where it remained stationary for a long time and then began to fall. When the same experiment was tried on dead tissue the resistance fell at once and remained stationary indefinitely. The results are shown in tables IV and IVa and fig. 4. The addition of solid anhydrous $CaCl_2$ gave a similar result, although the rise was not as great.

TABLE IV

ELECTRICAL RESISTANCE OF *Laminaria saccharina*

Time in hours	In sea water 1000 cc. + $CaCl_2$ 5 M 10 cc.	In sea water
0	1290	1320
$\frac{1}{3}$	1280	1320
$\frac{2}{3}$	1300	....
2	1380	1320
$2\frac{1}{3}$	1390	....
13	1390	1320

All readings were taken at 18° C.

[3] The temporary fall in resistance at the start was due to the increased conductivity of the solution contained in the apparatus and in the intercellular substance.

This experiment has a special interest as affording positive proof that the current passes through the protoplasm as well as through the intercellular substance,[4] for it is evident that the rise in resistance in these experiments can not be due to any cause other than a change in permeability of the protoplasm. The concentration of the ions of the sea water remains unchanged, and if they were able to penetrate as freely as they did before the addition of the

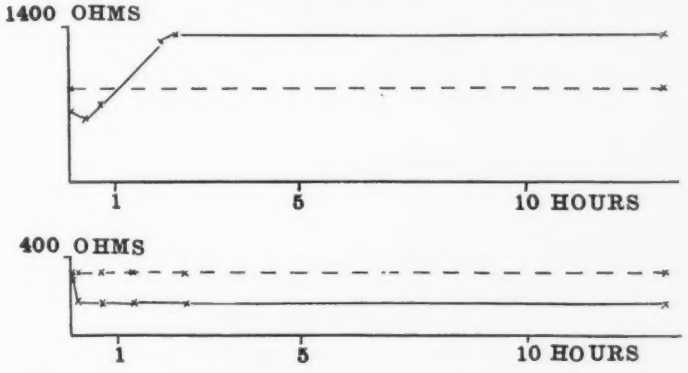

FIG. 4.—Curves of electrical resistance of live tissue (upper figure) and dead tissue (lower figure) of *Laminaria saccharina* in 1000 cc. sea water+10 cc. $CaCl_2$ 5 M (unbroken line in both figures) and of controls in sea water (dotted line in both figures).

TABLE IVa

ELECTRICAL RESISTANCE OF DEAD TISSUE OF *Laminaria saccharina*

Time in hours	In sea water 1000 cc. +$CaCl_2$ 5 M 10 cc.	In sea water
0	370	380
$\frac{1}{6}$	340	380
$\frac{2}{3}$	340	380
$1\frac{1}{3}$	340	380
$2\frac{1}{2}$	340	380
13	340	380

All readings were taken at 18° C.

$CaCl_2$ the resistance would not increase. It would, in fact, diminish on account of the increased conductivity of the solution held in the intercellular substance, as is clearly shown by experiments on dead tissue. That the change in permeability is in the

[4] The frond may be regarded as a mass of intercellular substance in which the protoplasmic masses are imbedded.

protoplasm and not in the intercellular substance is clearly shown by the fact that as soon as the protoplasm is killed, no rise is produced on adding solid $CaCl_2$. This is true when the means of killing is such as to produce no change in the intercellular substance, e.g., by slight reduction of the water content by partial drying, by allowing the material to stand in the laboratory until dead, or by raising the temperature to 45°C.

If the rise in resistance were not due to a change in permeability, it could be explained only as the result of a decrease in the size of

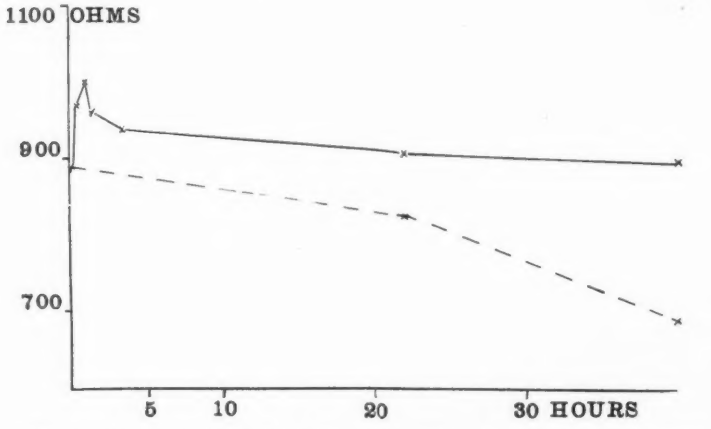

FIG. 5.—Curve of electrical resistance of *Laminaria saccharina* in sea water 1000 cc. + ($MnSO_4 + 7H_2O$) 1.39 gm. = (0.005 M) (unbroken line), and of a control in sea water (dotted line).

the spaces between the cells. Both macroscopic and microscopic measurements show most conclusively that this does not occur. The contrary effect would be produced by the addition of salts in solid form, for they would tend to produce plasmolysis and thereby to increase the space between the cells.

In order to test further the effect of $MgCl_2$, 10 cc. of a 5 M solution were added to 1000 cc. of sea water. A reading taken 5 minutes later showed that the resistance had fallen from 780 to 700 ohms; it continued to fall slowly throughout the experiment. The writer interprets this as showing that $MgCl_2$ is not able to

produce sufficient rise to overcome the effect of the increase in the conductivity of the solution which is contained in the intercellular substance.

The addition of $MnSO_4$ in solid form produced a decided rise as shown in table V and fig. 5. The amount added was sufficient to make the concentration 0.005 M.

TABLE V

ELECTRICAL RESISTANCE OF *Laminaria saccharina*

Time in hours	In sea water 1000 cc. + $MnSO_4$ 1.39 gm. (=0.005 M)	In sea water
0	890	890
½	970	...
1	1000	...
1½	960	...
3½	940	...
22	910	830
40	900	690

All readings were taken at 18° C.

It is evident that the addition (to sea water) of a salt in solid form is the severest possible test of its ability to produce a rise in resistance. In subsequent tests of other bivalent kations this method was exclusively employed.

In table VI and fig. 6 are shown the results of two experiments with $CaCl_2 + 6\ H_2O$ which was added to sea water in sufficient amount to make the concentration 0.005 M (1.19 gm. to 1000 cc. sea water). The course of the curves is not quite the same, the lower curve falling more rapidly than the upper. This difference is too great to be the result of experimental error and must be attributed to laboratory conditions and to differences in the material itself, which shows some variation in this respect unless gathered and cut at the same time. It will be noticed that the resistance of the control falls off more rapidly in the lower curve, which must be attributed largely to laboratory conditions. Dead tissue under the same conditions showed no rise in resistance.

TABLE VI

ELECTRICAL RESISTANCE OF *Laminaria saccharina*: TWO EXPERIMENTS

Time in hours	In sea water 1000 cc. ($CaCl_2+6H_2O$) 1.19 gm. (=0.005 M)	In sea water
0	930	890
$\frac{1}{4}$	1010	...
$\frac{1}{2}$	1020	...
1	1010	...
3	980	...
6	960	...
21	940	880
40	900	850
0	940	900
$\frac{1}{4}$	990	...
$\frac{1}{2}$	1020	...
1	1000	...
2	950	...
18	900	...
40	770	780

All readings were taken at 18° C.

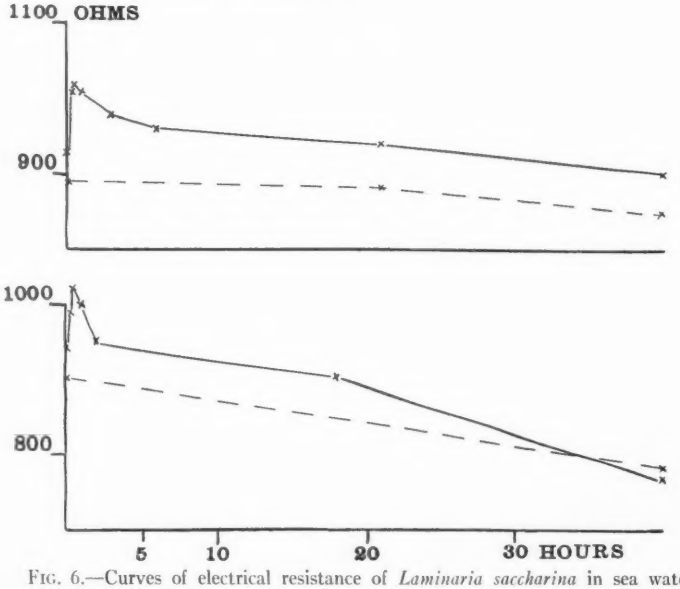

FIG. 6.—Curves of electrical resistance of *Laminaria saccharina* in sea water 1000 cc.+($CoCl_2+6H_2O$) 1.19 gm. (=0.005 M) (unbroken lines); two experiments; control in sea water (dotted lines).

Table VII and fig. 7 show the behavior of tissue in sea water to which sufficient $FeSO_4 + 7H_2O$ had been added to make the concentration 0.005 M (1.39 gm. to 1000 cc. sea water). Some precipitate formed after standing.

TABLE VII

ELECTRICAL RESISTANCE OF *Laminaria saccharina*

Time in hours	In sea water 1000 cc. ($FeSO_4+7H_2O$) 1.39 gm. (=0.005 M)	In sea water
0	910	890
$\frac{1}{4}$	1100	...
$\frac{1}{2}$	1040	...
$1\frac{1}{4}$	1000	...
$2\frac{1}{4}$	970	...
18	750	780
40	450	730

All readings were taken at 18° C.

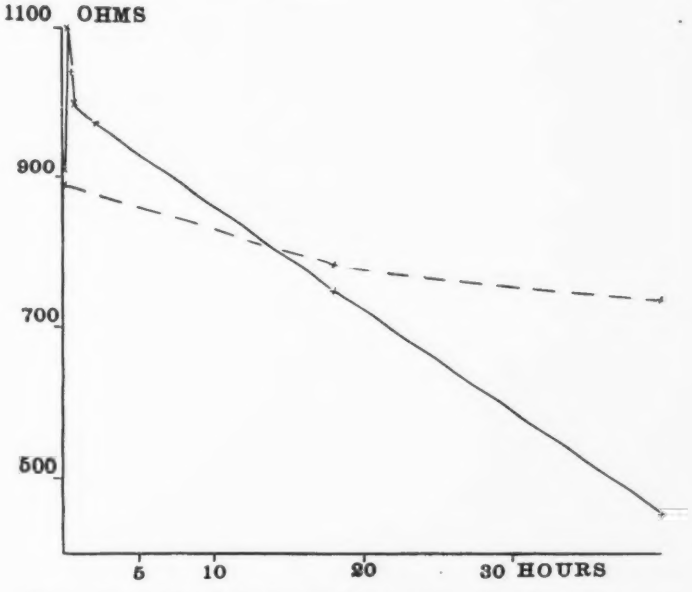

FIG. 7.—Curve of electrical resistance of *Laminaria saccharina* in sea water 1000 cc. +($FeSO_4+7H_2O$) 1.39 gm (=0.005 M) (unbroken line) and of a control in sea water (dotted line).

It will be noticed that while there is a very rapid and decided rise, the fall is much more rapid than in any of the previous experiments in which solid salts had been added to sea water. Neither of these effects can be attributed to acid, as the solution was neutral to litmus. After 18 hours the resistance was below that of the control and it continued to fall rapidly to the death point. Dead tissue showed no rise in resistance.

Table VIII and fig. 8 show the results of experiments in which sufficient $NiCl_2 + 6H_2O$ was added to the sea water to make the

TABLE VIII

ELECTRICAL RESISTANCE OF *Laminaria saccharina*

Time in hours	In sea water 1000 cc. ($NiCl_2 + 6H_2O$) 1.10 gm (=0.005 M)	In sea water
0	940	890
$\frac{1}{4}$	1000	...
$\frac{3}{4}$	1060	...
1	1020	...
2	1000	...
5	950	...
21	920	840
44	760	600

All readings were taken at 18° C.

concentration 0.005 M (1.19 gm. to 1000 cc. sea water). The results are similar to those obtained with $CoCl_2 + 6H_2O$. Dead tissue showed no rise in resistance.

Contrary to expectation the experiments with $ZnSO_4 + 7H_2O$ showed that it was less toxic than $FeSO_4 + 7H_2O$. The results are shown in table IX and fig. 9.

TABLE IX

ELECTRICAL RESISTANCE OF *Laminaria saccharina*

Time in hours	In sea water 1000 cc. ($ZnSO_4 + 7H_2O$) 1.44 gm. (=0.005 M)	In sea water
0	870	860
$\frac{1}{4}$	940	...
$\frac{1}{2}$	950	...
1	990	...
$1\frac{1}{2}$	970	...
3	920	...
19	830	720
40	700	640

All readings were taken at 18° C.

The concentration used waso .005 M (1.44 gm. to 1000 cc. sea water).

The curve obtained by using $CdCl_2 + 2H_2O$ is of a somewhat different type from those previously met with. The rise is not as

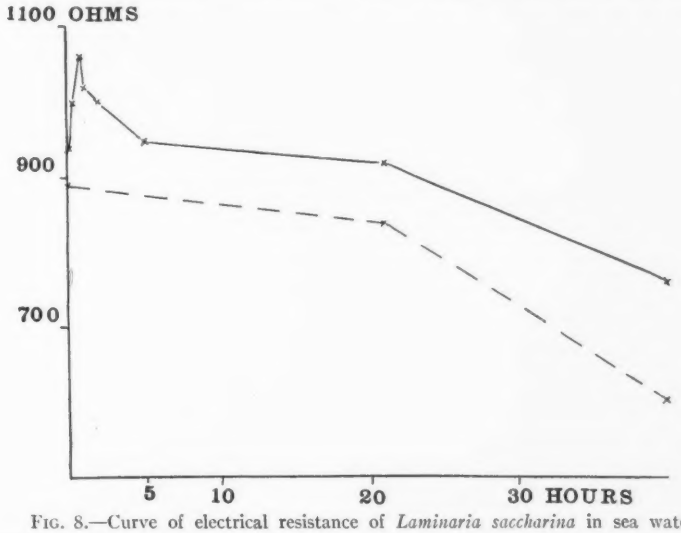

FIG. 8.—Curve of electrical resistance of *Laminaria saccharina* in sea water 1000 cc.+($NiCl_2$+$6H_2O$) 1.19 gm. (=0.005 M) (unbroken line) and of a control in sea water (dotted line).

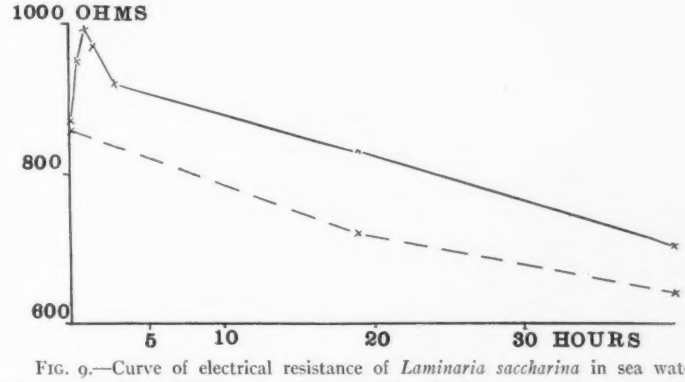

FIG. 9.—Curve of electrical resistance of *Laminaria saccharina* in sea water 1000 cc.+($ZnSO_4$+$7H_2O$) 1.44 gm. (=0.005 M) (unbroken line) and of a control in sea water (dotted line).

rapid nor as great and the fall is slow, especially at first. The concentration was 0.005 M (1.1 gm. to 1000 cc. sea water). The results are shown in table X and fig. 10. Dead tissue showed no rise in resistance.

TABLE X

ELECTRICAL RESISTANCE OF *Laminaria saccharina*

Time in hours	In sea water 1000 cc. ($CdCl_2+2H_2O$) 1.13 gm. (=0.005 M)	In sea water
0	850	860
$\frac{1}{4}$	900	...
1	920	...
2	930	...
$9\frac{1}{2}$	910	840
$22\frac{1}{2}$	870	820
45	600	680

All readings were taken at 18° C.

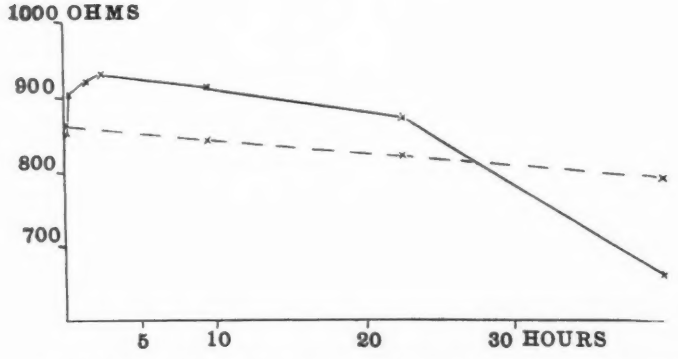

FIG. 10.—Curve of electrical resistance of *Laminaria saccharina* in sea water 1000 cc.+($CdCl_2+2H_2O$) 1.1 gm. (=0.005 M) (unbroken line) and of a control in sea water (dotted line).

A very different type of curve is obtained by using $SnCl_2+2H_2O$. The rise is rapid and decided and the fall is much more rapid than with any of the other substances used. The solution was acid to litmus, but the effect cannot be considered as due to the acidity alone. Dead tissue showed no rise in resistance.

Some precipitate formed on standing. The concentration used was 0.005 M (1.13 gm. to 1000 cc. sea water).

TABLE XI

ELECTRICAL RESISTANCE OF *Laminaria saccharina*

Time in hours	In sea water 1000 cc. ($SnCl_2+2H_2O$) 1.13 gm. (=0.005 M)	In sea water
0	780	750
¼	860	...
½	870	...
¾	880	...
1	830	...
1½	750	...
17	400	690
40	320	530

All readings were taken at 18° C.

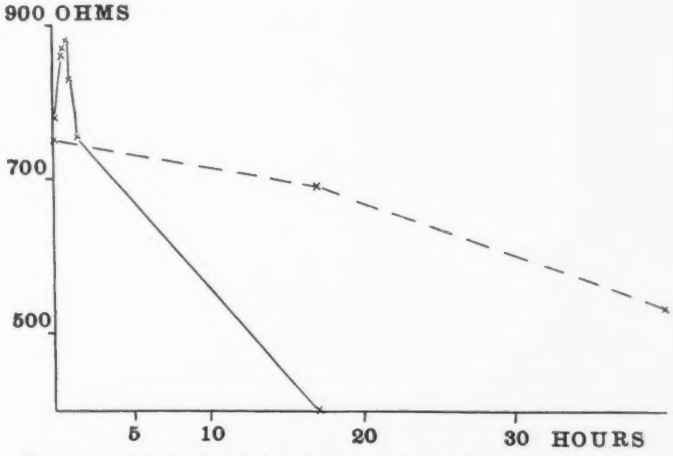

FIG. 11.—Curve of electrical resistance of *Laminaria saccharina* in sea water 1000 cc.+($SnCl_2+2H_2O$) 1.13 gm. (=0.005 M) (unbroken line) and of a control in sea water (dotted line).

It is evident that there is a remarkable difference between the chlorides of monovalent and the chlorides of bivalent kations in their effects on permeability. So far as the writer's experiments have gone, none of the chlorides of monovalent kations are able to decrease permeability (with the significant exception of HCl),

while all of the chlorides of bivalent kations are able to do so to a marked degree. Various tempting hypotheses are suggested by these striking facts. None of them can be worked out at present in a manner which is free from objection, and the writer deems it advisable to defer discussion of them until further investigations have been made.

Summary

There is a remarkable difference between monovalent and bivalent kations in their effects on permeability.

While none of the monovalent kations (except H) are able to decrease permeability, all the bivalent kations so far investigated (Mg, Ca, Ba, Sr, Mn, Co, Fe, Ni, Zn, Cd, Sn) are able to do so to a marked degree.

HARVARD UNIVERSITY

BRIEFER ARTICLES

NOTES ON ORCHIDS

(WITH ONE FIGURE)

CATTLEYA MOSSIAE Hooker.—Mr. KNUDSEN, of Boulder, Colorado, has been very successful in growing this fine species under glass. On one occasion, it was found that the flowers were being fertilized, and it turned out that this was done by *Bombus Huntii* Greene, which gained access to the greenhouse. I now possess one of these bees, with several *C. Mossiae* pollinia attached to the mesothorax. The case is interesting, since this species of bee has had of course no previous experience with *Cattleya* or with any closely related plant. Mr. KNUDSEN believes that honey bees do not pollinate *Cattleya*.

CYTHEREA BULBOSA (L.) House.—On June 8, 1914, my wife and I were able to study this plant in life at Gresham, Colorado. It grew on a damp hillside with a north exposure, under *Populus tremuloides* and young Engelmann spruce, with *Arnica cordifolia* Hook., *Chamaenerion angustifolium* (L.) Scop., and *Fragaria*. We were particularly anxious to see the process of pollination, but in this we were disappointed, owing to the bad weather. We saw no insects on the orchids, but a few *Bombus* were flying around. There can be little doubt that the work is done by *Bombus*, which bending down (almost standing on its head) to get the nectar, would receive the pollen on the upper side of its thorax. In Idaho this orchid is represented by a variety, *Cytherea bulbosa occidentalis* (*Calypso bulbosa occidentalis* Holzinger, Contrib. Nat. Herb. 3:251. 1895), in which the beard on the lip is white instead of yellow. In the Colorado form it is yellow. There is, however, some question whether the Colorado plant is the same as that of the northeastern states, so I give some descriptive details from the living plant as observed at Gresham.

Scape lilac; sepals and petals "similar, ascending, spreading" (AMES), magenta (nearly rose vineaux of GRAVEREAUX, but a little bluer), about 20 mm. long, the median sepal exceeding the lip (wholly different from the figure in BRITTON and BROWN'S *Illustrated flora*); sepals and petals 3-veined, but the veins not evident except on close

inspection; winged column exactly the color of sepals and petals, diameter 6.5 mm., apex truncate; lip 19 mm. long, 9.5 mm. broad near base, the basal half profusely streaked with dark crimson on a white ground within, the crimson occupying more than half the surface; at the end of the opening of the lip above is a lemon yellow patch with three rows of yellow hairs, and near the distal end of each row is a bunch of shorter, dark red, claviform hairs; the apical expansion of the lip is about 9 mm. long and 7 mm. wide (longer than in BRITTON'S figure), the apex briefly pointed, not widened or emarginate, as BRITTON'S figure shows; apical part of lip whitish, flushed with pink distally, but without dark spots except the three patches of claviform glands on the yellow area; beneath, the lip or sac ends in two hornlike processes, 2.5–3 mm. long, which do not extend beyond the apical extension above; these horns (which contain nectar) and the region about their base are pale yellowish.

FIG. 1.—*Antholithes pediloides*, n. sp.

CYPRIPEDIUM VEGANUM Cockerell and Barker.—I have grown this successfully in my garden at Boulder, the plants coming from the Upper Pecos. On May 24, 1914, I saw a female bee *Osmia armaticeps* Cresson enter the flower through the upper aperture of the lip, and eventually emerge at the side behind, following the route indicated by H. MÜLLER.[1] It forced its way out with considerable difficulty, the passage being almost too narrow for it. Smaller bees are able to crawl out by the way they came in, and consequently are not agents in pollination.

Antholithes pediloides, n. sp. (fossil).—Lip(?) apparently saccate, as preserved coffee-brown, much darker than the shale, a little over 12 mm. long; no venation visible (fig. 1).

This object, which I have repeatedly studied, has all the appearance of being the lip of a *Cypripedium*, showing a strong callus around the lateral sinuses, and even, by a dark shade, some indication of the margin of the sterile stamen. Comparison with living *Cypripedium* flowers appeared to confirm the identification. On the other hand, it appears very unlikely that a *Cypripedium* lip would be separated from the rest of the flower and preserved in this manner. I think we can say with certainty that the object is neither a fruit nor a leaf; the apparent lateral sinuses are not due to any accidental tearing or breaking. There remains, however, a feature which I cannot at present explain. Irregu-

[1] KNUTH, Blütenbiologie 2:459. 1899.

larly scattered over the surface are small round subhyaline spots, evidently representing perforations of the tissue. These are usually, but not always, in pairs. I suppose that they represent the work of some insect, but what one, I am quite at a loss to imagine.

The fossil was collected by Mr. GEO. N. ROHWER, at Station 14, in the Miocene shales of Florissant, Colorado.—T. D. A. COCKERELL, *University of Colorado, Boulder.*

CURRENT LITERATURE

BOOK REVIEWS

A textbook of grasses

We are familiar with books treating grasses from the standpoint of taxonomy or of agriculture, but to make this group the basis of a textbook rather than a book of reference is something unusual. Such a book has been written by HITCHCOCK,[1] and appears as one of "The rural textbook series," under the editorship of L. H. BAILEY. The two parts are "Economic agrostology" and "Systematic agrostology," so that the economic and taxonomic aspects of the group are prominent; nevertheless, the treatment is dominated by the textbook idea, and it is distinctly a teaching book. The titles under "Economic agrostology" are economic classification of grasses, forage plants, cultivated pastures, meadow plants, hay and green feed, lawns, grasses used for miscellaneous purposes, weeds, and grass crop areas. Under "Systematic agrostology" there is a notable textbook introduction under the following titles: morphology of the vegetative organs, morphology of the floral organs, ecology, and principles of classification. This introduction is followed by a taxonomic presentation of the group, which includes a key to all the genera found growing wild or in common cultivation in the United States. The more important genera are described more fully, as they should be, and the principle of selection has been to familiarize the users of the book with the grasses that deserve most attention.

The book will certainly prove very useful to a large and growing constituency, which should include not only rural communities and agricultural colleges, but also students of botany in colleges and universities.—J. M. C.

MINOR NOTICES

Flora of Jamaica.—The third volume of FAWCETT and RENDLE's *Flora of Jamaica*[2] begins the Dicotyledons. The first volume, published in 1910, included the orchids; while the second volume, not yet published, will include

[1] HITCHCOCK, A. S., A textbook of grasses with especial reference to the economic species of the United States. 8vo. xvii+276. *figs.* 63. New York: Macmillan. 1914. $1.50.

[2] FAWCETT, W., and RENDLE, A. B., Flora of Jamaica, containing descriptions of the flowering plants known from the island. Vol. III. Dicotyledons (Piperaceae to Connaraceae). 8vo. xxiv+280. *figs.* 113. *pls.* 5. Published by the British Museum. 1914.

the remainder of the Monocotyledons. It is estimated that the Dicotyledons will be completed in four volumes, making the completed work contain six volumes. Preceding the presentation of the families, there is a list of works referred to in the text, a list of names of collectors with the dates of their collections, a conspectus of the families, and a key to families.

The contrast with north temperate floras is striking. Out of 38 families presented, such conspicuous northern ones as Caryophyllaceae (7 spp.), Ranunculaceae (4 spp. of *Ranunculus* and *Clematis*), Cruciferae (6 spp.), and Rosaceae (9 spp.) are negligible elements of the Jamaican flora; while the large families are Urticaceae (55 spp.) and Piperaceae (52 spp.), the largest genera being *Pilea* (42 spp.) and *Peperomia* (38 spp.). The genera number 115 and the species 347, so that, omitting the two large families, the genera average only two species each.—J. M. C.

Flora of New Guinea.—In continuation of the Dutch exploration of the flora of New Guinea, two additional fascicles have appeared.[3] Previous parts were reviewed in this journal.[4]

The fascicle first cited contains the Liliaceae by HANS HALLIER, including 7 genera and 23 species, 8 of which are new; and Piperaceae and Meliaceae by C. DE CANDOLLE. The list of Piperaceae includes 15 species of *Peperomia*, 10 of which are new, and one species of *Piper;* while the Meliaceae are represented by the description of 12 new species.

The second fascicle cited contains the mosses by MAX FLEISCHER, a new genus (*Brotherobryum*) being described in Dicranaceae, and 6 new species in other genera; and Ericaceae by J. J. SMITH, 19 new species being described, mostly in *Vaccinium* and *Rhodendron*. The same author also describes a new *Clethra* and a new *Corsia*.—J. M. C.

Micrography of Javanese woods.—The fourth part of JANSSONIUS' micrography of the woods of Java has appeared,[5] including the Calyciflorae. The previous parts have been noticed in this journal,[6] the first notice describing the general purpose of the work. The present part begins with the Connaraceae and ends with Rhizophoreae. With all the species there are given

[3] Nova Guinea. Résultats de l'expédition scientifique Néerlandaise á la Nouvelle-Guinée en 1907 et 1909 sous les auspices de Dr. H. A. LORENTZ. Vol. VIII. Botanique. Livraison VI. 4to. pp. 989–1048. *pls. 180–188;* the same, L'expédition en 1912 et 1913 sous les auspices de A. FRANSSEN HERDERSCHEE. Vol. XII. Botanique. Livraison II. 4to. pp. 109–172. *pls. 29–54.* Leide: E. J. Brill. 1914.

[4] BOT. GAZ. **49**:464. 1910; **55**:462. 1913; **57**:342. 1914.

[5] JANSSONIUS, H. H., Mikrographie des Holzes der auf Java vorkommenden Baumarten. Vierte Lieferung. 8vo. Vol. III. pp. 1–336. *figs. 183.* Leiden: E. J. Brill. 1914. *M* 6.

[6] BOT. GAZ. **43**:345. 1907; **47**:616. 1909; **52**:67. 1911.

details of the vascular elements, list of reagents, sources of material, references to literature, etc., representing an amount of detailed work that few would care to undertake.—J. M. C.

NOTES FOR STUDENTS

Current taxonomic literature.—O. AMES (Philipp. Jour. Sci. Botany **8**:407–440. *pl. 13.* 1913) under the title "Notes on Philippine orchids with descriptions of new species VI" adds 47 new species to the Philippine flora.—E. G. BAKER (Jour. Bot. **52**:*2*, 3. 1914) has published a new genus *Talbotiella*) of the Leguminosae from Nigeria.—H. J. BANKER (Mycologia **5**:293–298. 1913) in continuation of studies on the Hydnaceae proposes a new genus (*Hydnodon*) based on *Hydnum thelephorum* Lévéille.—G. BEAUVERD (Bull. Soc. Bot. Genève II. **5**:205–228. 1913) under the general title "Contribution à l'étude des Composées" describes several new species and proposes the following new South American genera: *Stuckertiella*, based on *Gamochaeta capitata*, and *Berroa*, based on *Lucilia gnaphalioides*.—A. BÉGUINOT (Bull. Soc. Bot. Ital. 97–104. 1913) has published a new genus (*Eremophyton*) of the Cruciferae from Algeria.—A. BERGER (Rep. Sp. Nov. **12**:503. 1913) characterizes a new species of *Agave* (*A. Vilmoriniana*) from Mexico.—E. P. BICKNELL (Bull. Torr. Bot. Club **40**:605–624. 1913; **41**:71–87. 1914) in continuation of the contributions "The ferns and flowering plants of Nantucket" records new species in *Hypericum*, *Crocanthemum*, and *Oenothera*.—G. BITTER (Rep. Sp. Nov. **12**:433–467, 542–555. 1913; **13**:88–103, 169–173. 1914) in continuation of his studies on the genus *Solanum* records further new species, chiefly from Central and South America. The same author (*ibid.* **12**:477–480. 1913) characterizes 5 new varieties of *Polylepis australis* and a new subspecies of *Acaena polycarpa* from Argentina.—A. BRAND (Ann. Conserv. et Jard. Bot. Genève **15** and **16**:322–342. 1913) in an article entitled "Neue Beiträge zur Kenntnis der Polemoniaceen" presents important data supplementing his recent monograph of this family and adds several new species and varieties. The same author (*ibid.* 343, 344) describes two new species of *Symplocos* from America, and (Rep. Sp. Nov. **13**:81–83. 1914) characterizes two new genera of the Borraginaceae, namely *Lacaitaea*, founded on *Trichodesma calycosum* Collet and Hemsl. of East India, and *Vaupelia* to which are referred six tropical African species hitherto included under *Trichodesma*.—E. G. BRITTON (Bull. Torr. Bot. Club **40**:653–676. *pl. 25.* 1913) publishes a preliminary article on West Indian mosses. The author gives rather extended synonomy and bibliography and makes new combinations in *Neckera*, *Clastobryum*, *Palamocladium*, and *Turckheimia*.—E. G. BRITTON and R. S. WILLIAMS (Torreya **14**:24–31. 1914) under the heading of "Central American mosses" list 54 species and include a new genus (*Isodrepanium* [Mitt.] E. G. Britton) based on *Homalia lentula* Wils.—L. BUSCALIONI and G. MUSCATELLO (Malpighia **26**:1–32, 49–56, 97–144. 1913) in continuation of their studies on the genus *Saurauia* have added three new species from Central and South America.—J. CARDOT (Rev.

Bryol. **40**:22, 23. 1913) has proposed a new genus (*Hylocomiopsis*) based on *Anomodon ovicarpus* Besch. of Japan.—T. D. A. COCKERELL (Torreya **13**:265–273. 1913) in an article on "Some plants from the vicinity of Longs Peak Inn, Colorado," makes new combinations and records new forms in *Polemonium* and *Senecio*.—O. F. COOK (Contr. U.S. Nat. Herb. **16**:277–285. *pl. 101*. 1913) under the title "Nomenclature of the sapote and the sapodilla" gives a brief historical account of these plants and proposes a new generic name for the sapote, namely *Achradelpha mammosa* (L.) Cook.—C. DE CANDOLLE (Coll. of Hawaii Pub. Bull. no. 2. pp. 5–38. *pls. 1–8*. 1913) has published an article entitled "The Hawaiian Peperomias" in which he recognizes 73 species of *Peperomia* of which 47 are new to science.—H. DIEDICKE (Ann. Mycol. **11**: 528–545. 1913) in critical notes on certain fungi characterizes a new genus (*Psilosporina*) based on *Psilospora Quercus* Rabenh.—S. T. DUNN (Kew Bull. 145–153. 1913) gives a synoptical revision of the Pacific North American genus *Marah*, recognizing 11 species two of which are new to science.—A. D. E. ELMER (Leafl. Philipp. Bot. **5**:1751–1905; and **6**:1919–1986. 1913) in cooperation with several specialists has issued articles 93–100, inclusive, which contain descriptions of 166 new species of Philippine plants. The following new genera are proposed: *Schizochora* and *Cyclodothis* Syd. of the Ascomycetes, *Diedickea* Syd., placed in "Fungi Imperfecti," and *Elmerobryum* Broth. of the Hypnaceae.—A. ENGLER (Bot. Jahrb. **51**:1–163. 1913) in cooperation with several noted specialists has published the forty-second contribution to the flora of Africa. The families treated here are the Malvaceae, Oleaceae, Violaceae, and Asclepiadaceae. Many new species are described and the following new genera are proposed: *Campanolea* Gilg and Schellenberg of the Oleaceae, *Stigmatorhynchus*, *Blepharanthera*, *Siphonostelma*, and *Kinepetalum* Schlechter of the Asclepiadaceae.—A. J. EWART (Proc. Roy. Soc. Victoria **26**:1–11, 152–164. *pls. 1–2, 14–15*. 1913) in cooperation with B. REES and A. MORRISON has issued "Contributions to the flora of Australia, nos. 20, 21." Several new species of flowering plants are described, and one new genus (*Reesia* Ewart) of the Amarantaceae is included.—A. J. EWART and B. REES (*ibid.* **25**:105–114. *pls. 5, 6*. 1912) under the title "Contribution to the flora of Australia, no. 19" record several plants as new to or little known in Australia and include a new genus (*Huxleya*) of the Verbenaceae.—K. FRITSCH (Bot. Jahrb. **50**:392–439. 1913) under the title "Beitrag zur Kenntnis der Gesnerioideae" has published 34 species new to science and characterizes a new genus (*Fiebrigia*) of the Gesneriaceae from Bolivia.—M. GANDOGER (Bull. Soc. Bot. Fr. IV. **13**:454–462. 1913) includes the descriptions of several new species of American flowering plants, particularly in the genus *Polygala*.—P. W. GRAFF (Philipp. Jour. Sci. Botany **8**:299–309. *pls. 8–10*. 1913) records important data on the basidiomycetous flora of the Philippines and includes 7 species new to science.—J. M. GREENMAN (Torreya **13**:257, 258. 1913) has published a new species of *Senecio* (*S. eriocarphus*) from Cuba.—H. HALLIER (Recueil Trav. Bot. Néerl. **10**: 340–355. 1913) characterizes a new genus (*Schuurmansiella*) of the Ochnaceae,

based on *Schuurmansia angustifolia* Hook. f. from Borneo. In the same article the author adds a new species to the genus *Blastemanthus* from Brazil.—R. HAMET (Bot. Jahrb. **50**: Beibl. no. 112. pp. 8–12. 1913) has published new species of *Sedum*, including 3 from Peru. The same author (Rep. Sp. Nov. **12**:407–411. 1913) adds 3 additional species to this genus from Mexico, and (Field Mus. Nat. Hist. Bot. Ser. **2**:378–379. 1913) records two more from Guatemala.—E. HASSLER (Rep. Sp. Nov. **12**:365–374, 495–499. 1913) has published several new species, varieties, and forms of Malvaceae, Leguminosae, Anacardiaceae, and Compositae from South America. The same author (Bull. Soc. Bot. Genève **5**:266–277. 1913) under the title "Revision critique des Oenothéracées du Paraguay" characterizes several new varieties and forms.—B. HAYATA (Bot. Jahrb. **51**:164–176. *pl. 1.* 1913) gives a detailed and very interesting account of the morphology and systematic position of the recently published genus *Mitrastemon*, placing it in the Rafflesiaceae under the tribal name *Mitrastemoneae* which is coordinate with and immediately following the *Apodantheae*.—B. P. G. HOCHREUTINER (Ann. Conserv. et Jard. Bot. Genève **15** and **16**:297–303. *pl. 1.* 1913) has published a new genus (*Bakeridesia*) of the Malvaceae from Mexico.—L. S. HOPKINS (Am. Fern. Jour. **3**:116–118. *pl. 9.* 1913) describes and illustrates a new species of fern (*Polysticum Andersoni*) from Vancouver Island, British Columbia.—H. D. HOUSE (Torreya **14**:2–4. 1914) records a new hybrid violet (*Viola emarginata*×*septemloba*) from southeastern Virginia. The same author (Muhlenbergia **9**:81–100. 1914) under the title "Vegetation of the Coos Bay region, Oregon" gives a list of the plants collected during two seasons and includes the description of a new species, namely *Vancouveria brevicula* Greene.—J. HUBER (Bol. Mus. Goeldi **7**:199–281. 1913) in an article on the genus *Hevea* adds two hitherto undescribed species from South America. The same author (*ibid.* 283–307) under the title "Sobre una collecçao de plantas da região de Cupaty" describes 15 species new to science and includes a new genus (*Nealchornea*) of the Euphorbiaceae.—O. JIMÉNÉZ (Bol. de Fomento, Costa Rica **3**:661–667. 1913) has published an account of a new arborescent fern (*Cyathea gemmifera* Christ) from Costa Rica.—H. JUMELLE and H. PERRIER (Ann. Mus. Col. Marseille III. **1**:1–91. *pls. 1–43.* 1913) have published an important contribution to our knowledge of the palms of Madagascar, describing and illustrating several species new to science.—E. KOEHNE (Bot. Jahrb. **51**:177–224. 1913) gives a synopsis of the genus *Pygeum*, recognizing 65 species. The article includes several species new to science from the Philippine Islands.—F. KRÄNZLIN (Bull. Jard. Imp. Bot. St. Petersburg **13**:89–94. 1913; Rep. Sp. Nov. **13**: 117–120, 160, 161. 1914; Kew Bull. pp. 188–192. 1913; Bot. Jahrb. **50**: Beibl. no. 112. pp. 1–7. 1913) has published new species of *Buddleia*, several Amaryllidaceae, and other flowering plants from Mexico, Central and South America. The same author (Philipp. Jour. Sci. Bot. **8**:311–33. 1913) under the title "Cyrtandraceae novae philippinenses II" has published 34 new species mostly of the genus *Cyrtandra*.—G. KÜKENTHAL (Rep. Sp. Nov. **13**:135, 136.

1914) describes several new Cyperaceae including a new species of *Rhynchospora* (*R. Ostenii*) from Uruguay.—A. E. LECHMERE (Bull. Soc. Myc. France **29**:303–331. *pls. 20, 21.* 1913) under the title "Description de quelques Moisissures nouvelles provenant de la Côte d'Ivoire" characterizes a new genus (*Peristomium*) of the Sphaeriaceae from French Congo.—G. LINDAU (Rep. Sp. Nov. **12**:423–426. 1913) has published 5 new species of Acanthaceae from Central America.—TH. LOESENER (Verh. Bot. Ver. Prov. Brandb. **55**:151–194. 1913) in cooperation with several specialists has published the eighth article under the general title "Plantae Selerianae." Several species new to science are described.—J. LUNELL (Am. Mid. Nat. **3**:135–140. 1913) under the title "*Rosa* in North Dakota" includes descriptions of three new species, and (*ibid.* 141–148) characterizes several new species and varieties of flowering plants from North Dakota and a new *Rhus* from Nebraska.—K. K. MACKENZIE (Bull. Torr. Bot. Club **40**:529–554. 1913) continues "Notes on *Carex*" and gives a key to the *Montanae* group, recognizing 14 species of which 5 are designated as new. The same author (Torreya **14**:67, 68. 1914) has described a new genus (*Geocarpon*) of the Aizoaceae.—R. MAIRE (Ann. Mycol. **11**:331–358. *pls. 16–18.* 1913) under the title "Études mycologiques" includes descriptions of the following new genera: *Amanitella*, *Rhodopaxillus*, and *Periolopsis*.—G. O. MALME (Arkiv för Botanik **13**: no. 3. pp. 1–103. 1913) under the title "*Xyris* L. Untergattung *Nematopus* (Seubert), Entwurf einer Gleiderung" presents a synopsis of the group and describes several new species from South America.—S. C. MASON (Jour. Agr. Research **1**:147–178. *pls. 9–16.* 1913) describes and illustrates several hybrids and a new species of *Prunus* from southwestern United States.—E. D. MERRILL (Philipp. Jour. Sci. Botany **8**:31–63. *pl. 1.* 1913) under the title "Studies on Philippine Rubiaceae I" includes descriptions of 35 new species. The same author (*ibid.* 335–360. *pls. 11, 12*) in a second paper on "Philippine Melastomaceae" presents a consideration of the tribe *Astronieae*, describing 14 new species in *Astronia*, one in *Beccarianthus*, and proposes a new monotypic genus *Everettia* (*E. pulcherrima*); also (*ibid.* 363–390) under the title "Plantae Wenzelianae" includes diagnoses of 28 new species of flowering plants, collected near Dagami, Leyte, P.I.—G. K. MERRILL (Ottawa Nat. **27**:117–121. 1913) records several new and noteworthy lichens from Vancouver Island and the Rocky Mountains.—C. MEZ (Rep. Sp. Nov. **12**:411–421. 1913) has published new species of Bromeliaceae from the West Indies and South America.—C. F. MILLSPAUGH (Field Mus. Nat. Hist. **2**:353–377. 1913) presents the results of studies in the Euphorbiaceae and gives a synoptical revision of *Pedilanthus*, recognizing 31 species of which 9 are designated as new. *Cubanthus* which was treated by BOISSIER as a section under *Pedilanthus* is raised to generic rank and two species are referred thereto. One new genus (*Dendrocousinia*) is characterized from Jamaica.—C. E. MONROE (Bull. Wis. Nat. Hist. Soc. **11**:74–105. 1913) has published a paper on the "Wild asters of Wisconsin" and includes a catalogue of 60 recognized species and varieties.—G. V. NASH (Torreya **13**:273–

274. 1913) describes two new species of American grasses.—J. A. NIEUWLAND (Am. Mid. Nat. **3**:170–197. 1914) under the title "Critical notes on new and old genera of plants I" proposes several new generic names and makes a number of new combinations.—J. A. NIEUWLAND and R. M. KACZMAREK (*ibid.* 207–217. 1914) present a generic segregation of *Viola*.—I. OCHOTERENA (Mem. Soc. Alzate **33**:93–113. *pls. 6–21.* 1913) under the title "Plantas Deserticas Mexicanas" describes and illustrates several species of *Agave* and *Yucca*, including the following new to science: *A. complicata* and A. *quiotifera* Trelease.—E. PALLA (Oesterr. Bot. Zeitschr. **63**:401–404. 1913) has published 5 new species of Cyperaceae from Mexico.—C. H. PECK (N.Y. State Mus. Bull. 167. pp. 1–52. *pls. 131, 132,* ix, x. 1913) records important data concerning the flora of New York and includes descriptions of several new species of fungi.—H. PITTIER (Sm. Misc. Coll. **63**: no. 4. pp. 1–4. 1914) in an article on the "Relationship of the genus *Aulacocarpus*" has described a new species (*A. completens*) from Panama.—L. QUEHL (Monats. für Kakteenkunde **23**:181. 1913) has published a new species of *Mamillaria* (*M. arida*) from Lower California.—L. RADLKOFER (Philipp. Jour. Sci. Bot. **8**:443–473. 1913) gives an enumeration of the Sapindaceae of the Philippine Islands, recording 116 species of which 27 are new to science. Two new genera are proposed, namely *Gleocarpus* and *Gongrospermum*.—H. REHM (*ibid.* 391–405) in a third article on Philippine Ascomycetes includes descriptions of 24 new species and several varieties.—J. F. ROCK (Coll. Hawaii Pub. Bull. no. 2. pp. 39–49. *pls. 9–12.* 1913) under the title "New species of Hawaiian plants" has described new species and varieties of flowering plants.—R. A. ROLFE (Kew Bull. 1913. pp. 141–145, 338–343) has published new species of orchids including 7 from Central and South America.—J. N. ROSE (Sm. Misc. Coll. **61**:no. 12. pp. 1, 2. *pl. 1.* 1913) records a new poplar (*Populus MacDougalii*) from the southwest.—E. ROSENSTOCK (Rep. Sp. Nov. **12**:468–477. 1913) has published several species and varieties of ferns from Bolivia based on collections of Dr. O. BUCHTIEN.—H. ROSS (Mem. Soc. Alzate **32**:155–199. *pls. 11–13.* 1913) in cooperation with specialists has published under the heading "Contributions à la flore du Mexique" a list of plants obtained on excursions in connection with the Tenth International Geological Congress held in Mexico City in 1906. The present paper concerns the groups from lichens to lycopods inclusive, records important data, and includes a description and illustration of a new fern (*Dryopteris Rossii*).—P. A. SACCARDO (Ann. Mycol. **11**:312–325, 546–568. 1913) under the title "Notae mycologicae" has published numerous new species of fungi and proposes the following new genera: *Haraea* and *Actinopelte* from Japan, and *Melanographium*, *Traversoa*, and *Stigmatomyces* from the Philippine Islands.—P. A. SACCARDO and A. TROTTER (*ibid.* 409–420) in an article entitled "Fungi Tripolitani" include a description of a new hymenomycetous genus *Lacellina*.—C. S. SARGENT (N.Y. State Mus. Bull. no. 167. pp. 53–124. 1913) gives a synopsis of the genus *Crataegus* as represented in New York, recognizing 219 species of which 26 are described as new.—H.

SCHENCK (Rep. Sp. Nov. **12**:360–363. 1913) has published 10 new species of *Acacia* from Mexico and Central America.—R. SCHLECHTER (*ibid.* 481–495) describes 30 new species of orchids from Bolivia. The same author (Ann. Mus. Colon. Marseille III. **1**:148–202. *pls. 1–24.* 1913) contributes an important article on the orchids of Madagascar, describing and illustrating about 50 species new to science.—M. SLOSSON (Bull. Torr. Bot. Club **40**:687–690. *pl. 26.* 1913) has described a new *Trichomanes* from Colombia and a new *Polystichum* from Cuba.—W. W. SMITH (Rec. Bot. Surv. Ind. **4**:323–431. 1913) under the title of "The alpine and subalpine vegetation of Southeast Sikkim" gives a detailed account of a botanical survey of this region and lists 925 species of plants. Several species new to science are included, and one new genus (*Paroxygraphis*) of the Ranunculaceae is characterized.—O. STAPF (Kew Bull. 1913. pp. 354, 356) has published two new genera (*Chlamydoboea* and *Dichiloboea*) of the Gesneriaceae from tropical Asia.—J. STUCHLIK (Beih. Bot. Centralbl. **30**^{2}:392–411. 1913) under the heading "Über einige neue Formen von *Gomphrena*" records several new forms of this genus from America. The same author (Rep. Sp. Nov. **12**:516–524. 1913) in continuation of his studies on *Gomphrena* describes additional new varieties and forms.—D. R. SUMSTINE (Mycologia **6**:32–36. *pls. 115–117.* 1914) under the title "New or interesting fungi" describes new species and proposes a new genus (*Hormisciopsis*).—W. T. SWINGLE and M. KELLERMAN (Jour. Agr. Research **1**:419–436. *pl. 49.* 1914) have described a new genus (*Citropsis*) of the Rutaceae and have transferred thereto five species. The genus is based upon *Limonia Preussii* Engler, a species native of Kamerun which seems to possess economic possibilities.—H. and P. SYDOW (Philipp. Jour. Sci. Bot. **8**:475–508. 1913) continue their enumeration of the Philippine fungi and characterize the following new genera: *Bulgariastrum*, *Calopeziza*, *Sirosphaera*, and *Lasiothyrium*. The same authors (Ann. Myc. **11**:402–408. 1913) under the heading "Novae fungorum species XI" describe several new species and propose the following genera: *Micropeltella*, based on *Micropeltis albomarginata* Speg. from the Philippine Islands, and *Petrakia*, based on *Epicoccum echinatum* Pegl. from Austria.—F. THEISSEN (*ibid.* 425–467. *pl. 20;* 493–511. *pl. 21.* 1913) has published several new species of South American fungi and characterizes the following new genera: *Amazonia*, *Thallochaete*, *Myxomgriangium*, and *Heterostoma* from Brazil; also *Morenoina*, based on *Morenoella antarctica* Speg., and *Lembosina*, based on *Lembosia copromya* B. R. S.—C. TORREND (Broteria Ser. Bot. **11**:165–181. 1913) under the title "Troisième contribution pour l'étude des champignons de l'ile de Madère" continues the enumeration of species including several new to science and proposes a new genus (*Menezesia*) of the Protomycetaceae.—W. TRELEASE (Ann. Conserv. et Jard. Bot. Genève **15** and **16**:351. 1913) describes a new species of *Phoradendron* from Colombia.—E. ULBRICH (Verh. Bot. Ver. Prov. Brandbg. **55**:50–54. 1913) has published a new genus (*Selera*) of the Malvaceae, related to *Gossypium*, from Mexico.—I. URBAN (Rep. Sp. Nov. **13**:152–159. 1914) records the results of further study in the

Turneraceae describing new species in *Piriqueta* (2) and *Turnera* (3) from South America.—H. F. WERNHAM (Jour. Bot. **51**:320–324. 1913) under "New Rubiaceae from Tropical America III" has published 10 new species.—Ö. WINGE (Arkiv för Botanik **12**: no. 9. pp. 1–39. *pls. 1–13*. 1913) under the title "Cytological studies in the Plasmodiophoraceae" includes a description of a new genus and species (*Sorodiscus Callitrichis* Lagerh. and Winge) found on stems of *Callitrichis vernalis*.—H. W. WOLLENWEBER (Phytopathology **3**: 197–242. *pls. 20–22*. 1913) characterizes a new genus (*Cylindrocarpon*) based on *Nectria cucurbitula* (Tode) Fries.—N. WORONICHIN (Monit. Jard. Bot. Tiflis, Livr. 28. pp. 16–25. 1913) has published several new species of parasitic fungi including a new genus (*Echinosporium*) found on leaves of *Acer Pseudoplatanus* L. in the Caucasus region.—K. YENDO (Nyt Mag. f. Naturv. **51**:275–288. *pls. 13, 14*. 1913) under the title "Some new algae from Japan" describes and illustrates a new genus and species of parasitic alga, namely *Benzaitenia yenoshimensis*. The same author (Trav. Mus. Bot. and Acad. Imp. Sci. St. Pétersbourg **10**:114–121. 1913) presents a discussion of *Haplosiphon filiformis* Rupr. and proposes a new genus (*Ruprechtiella*), based on a part of RUPRECHT'S material in the Herbarium of the Academy of Science in St. Petersburg.—J. M. GREENMAN.

Tree growth.—Measuring the growth in height of over 40 specimens of *Pinus ponderosa* for the five years of 1909–1913, and attempting to correlate these increments with the precipitation during the growing period, KIRKWOOD[7] concludes that the amount of growth is determined principally by the moisture conditions of the preceding growing season. This he shows to be directly in harmony with the fact that the time of increase in height and thickness in trees is limited to the first few weeks of the growing season. His quantitative data seem to warrant such a conclusion, at least for regions of limited rainfall, where the seasons of maximum precipitation would approach most nearly to the optimum requirements of the tree.

Investigations of a somewhat similar nature by JACCARD[8] include observations upon a small number of individuals of several different species during the growing seasons of 1911 and 1912. The former was the warmer, drier year, and showed a greater increase in thickness in three examples compared with six examples exhibiting the greater increment in the latter year. He also shows that the period in which most of the increase in size is accomplished is during the first half of the season, or more exactly from May until the middle of July. He makes no attempt to trace the connection between the growth of one season with the weather conditions of the previous year.

[7] KIRKWOOD, J. E., The influence of the preceding growing season on the growth of the yellow pine. Torreya **14**:115–125. 1914.

[8] JACCARD, P., Accroisement en épaisseur de quelques conifères en 1911–1912. Jour. Forestier Suisse, nos. 6, 7, 8. pp. 1–20. 1913.

In a more extensive investigation, KAPTEYN[9] regards it important that the data of tree growth, to be reliable, should be from trees in rather extensive forests, well situated with respect to subsoil water, and where the conditions over considerable areas are uniform. His own data were derived from annual ring measurements of oaks taken from the forests along the rivers Main, Moselle, and Rhine, and include the increments for the past two centuries. During this period the fluctuations in growth rate showed parallel variations in the three forests, and these variations correlated with meteorological records lead him to the conclusions that: (1) the very considerable fluctuations in the yearly growth of the oaks in the forests under consideration must, in large part, be due to meterological influences; (2) temperature has had a very small influence; (3) the rainfall of the spring and summer is the factor of the most importance, but its influence may be different for different kinds of trees; (4) increased growth seems to be caused by a greater supply of subsoil water rather than by any more direct action of greater precipitation; (5) for at least the last 70 years of the period there was but a single growth ring produced each year; (6) there appears to be a rather constant periodicity of 12.4 years in the rate of growth of these trees, and a comparison with some specimens of *Sequoia* from California would indicate a similar periodicity in their annual increment.

All these papers are suggestive rather than conclusive in their results, and indicate the importance of more extensive data before very definite conclusions can be reached.—GEO. D. FULLER.

First-generation maize hybrids.—COLLINS[10] has described a method of comparing the yield of first-generation hybrids between distinct varieties of maize with the yield of the parent varieties. The principal difficulties with methods heretofore in use are thought to have arisen from failure to appreciate (1) the importance of individual diversity in such hybrids as well as in the parent varieties, (2) the abnormal behavior of self-pollinated maize plants, and (3) the necessity of securing for the comparison hybrids and parents of identical ancestry. Briefly, the method suggested for obtaining the material for comparison is to select two plants, *1* and *2*, from each of two varieties, *A* and *B*, and by hand-pollination to make the four combinations represented by $A1 \times A2$, $A2 \times B1$, $B1 \times B2$, and $B2 \times A1$, resulting in one cross-pollinated ear of each variety and two ears representing the hybrid between the varieties. The reviewer does not doubt that, if a considerable number of these sets of four ears were similarly obtained, the method would afford an accurate means of comparing the yields of maize varieties as they exist with the yields of first-generation crosses between these varieties, and that it should therefore be of

[9] KAPTEYN, J. C., Tree growth and meteorological factors. Rec. Trav. Bot. Néerland. 11:70–93. 1914.

[10] COLLINS, G. N., A more accurate method of comparing first-generation maize hybrids with their parents. Jour. Agric. Research 3:85–91. 1914.

no little value in practical agronomic tests. But he is not prepared to accept the author's idea that the proposed method affords a reliable means of "measuring the effect of crossing apart from other factors that influence yield." The method does not afford a comparison between the hereditary yielding power (effect of genetic factors influencing yield) on the one hand, and on the other the effect of these same genetic factors plus the effect of crossing (heterozygosis?). Since pronounced individual diversity exists in all ordinary maize varieties, the comparison offered is in reality between (1) the effect of certain genetic factors plus the effect of crossing between somewhat unlike individuals (an unknown degree of heterozygosis ?), and (2) the effect of the same genetic factors plus the effect of crossing between individuals presumably, though not necessarily, more unlike (a presumably considerable though wholly unknown degree of heterozygosis ?).—R. A. EMERSON.

Aspen in reforestation.—Experimental evidence is presented by PEARSON[11] of the extent to which the aspen assists in reforestation by promoting the vigor of conifer seedlings. The experiments were conducted by comparing the survival and condition of young Douglas fir (*Pseudotsuga Douglasii*) planted on similar areas with and without aspen cover, the results being decidedly better in the former localities. Measurements of the evaporating power of the air in the two situations show it to be decidedly less among the aspens, and to this is ascribed the better success of the young Douglas firs. Data upon soil moisture are less convincing, particularly from the absence of any constant, such as the wilting coefficient, to determine the availability of the moisture which is present. Incidentally, attention is directed to the importance of vegetative reproduction in the establishment of the aspens.—GEO. D. FULLER.

Sporophyte of liverworts.—Using the sporophyte of Hepaticae as a basis of classification, DOUIN[12] would make three groups as follows: those with the sporophyte reduced to a capsule (Ricciales); those with foot and capsule only (Anthocerotales); and those with foot, seta, and capsule (all of the rest of the liverworts). Although regarding the Anthocerotales as a very natural group, he objects strongly to making them coordinate with Hepaticae and Musci. The reviewer's recent studies of Mexican and Polynesian Anthocerotales, especially a form from Samoa, most emphatically bear out DOUIN's view. DOUIN concludes that the Jungermanniaceae Acrogynae, although now divided very artificially by various writers, are a far more natural assemblage than are the Anacrogynae, which as now arranged are the most artificial assemblage among Hepaticae.—W. J. G. LAND.

[11] PEARSON, G. A., The rôle of the aspen in the reforestation of the mountain burns in Arizona and New Mexico. Plant World **17**:249–260. 1914.

[12] DOUIN, ROBERT, Le sporophyte chez les Hepatiques. Rev. Gén. Botanique **24**: 403–413, 453–463. *pls. 18–21.* 1912.